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Serving A State Institution

ISOLATED PLANT FURNISHES THE I. S. F. M. Y. WITH ALL MODERN MECHANICAL AND ELECTRICAL COMFORTS, MAKING IT INDEPENDENT OF INDIVIDUAL CORPORATIONS

AT THE Indiana School for Feeble Minded Youths peculiar conditions exist which demand a diversified service from the power plant. The school is a state institution situated in Ft. Wayne, designed to aid the unfortunate youths, giving them a schooling as high as the eighth grade, as well as an industrial training, which will serve them as a livelihood, should they be restored to normal condition.

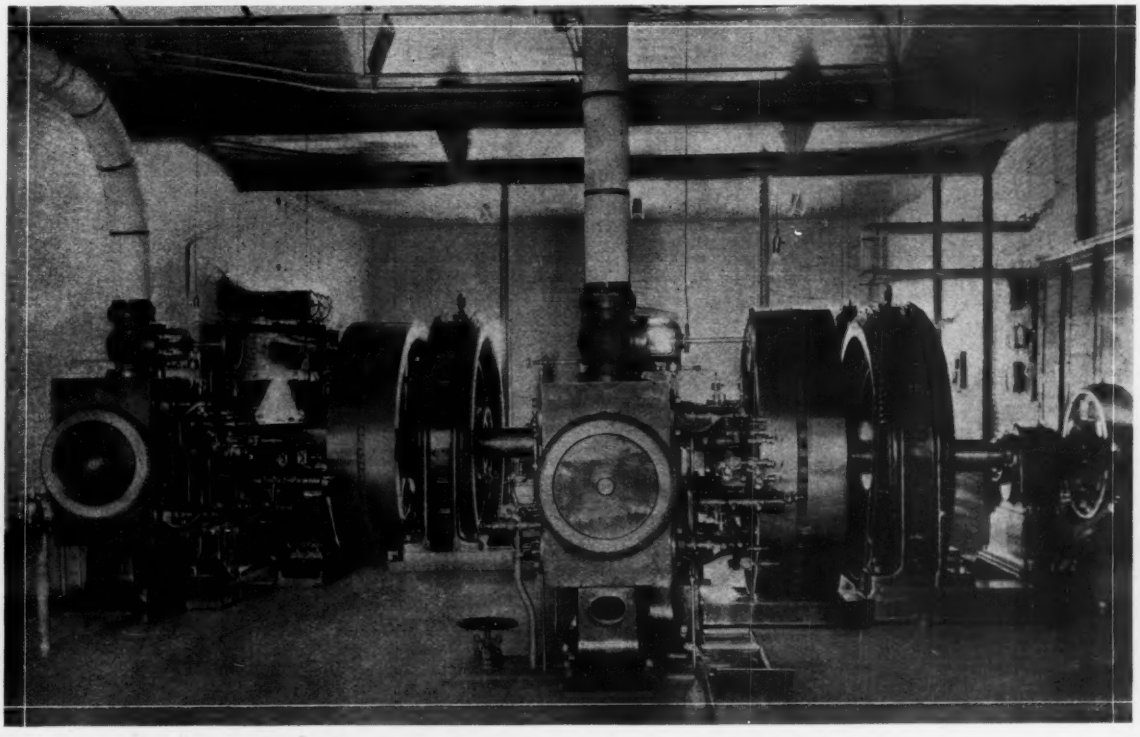


FIG. 1. GENERATING UNITS IN THE I. S. F. M. Y. PLANT

The power plant serves, therefore, the various dormitories, school buildings, hospital, shops, and the like, with light, power, water, heat, ice and refrigeration. It also serves the farm, which is 2½ mi. distant, with light and power, thus putting it in a class with central stations, but on a small scale.

BOILER ROOM

A PECULIARITY of this plant is that the lower class of labor costs nothing—in fact, serves as "busy work" for a number of inmates—so that labor-saving devices have not been provided, although the arrangement of apparatus is planned to lighten the work of all employes.

Coal is delivered in wagons to a covered storage, the wagons being hauled onto a platform, at grade level, extending through the building. From here it may be

dumped or shoveled into the bin below and to either side. The bottom of the bin is on a level with the firing floor of the boiler room, to which the coal is delivered in wheelbarrows. Handling of coal and ashes, as well as a share of the firing, is done by inmates of the school under supervision of experienced men.

Steam-generating equipment consists of 8 return-tubular boilers made by the Bass Mfg. Co. with a total rating of 1300 hp.; two of these boilers are, however, used at present for heating water for domestic purposes.

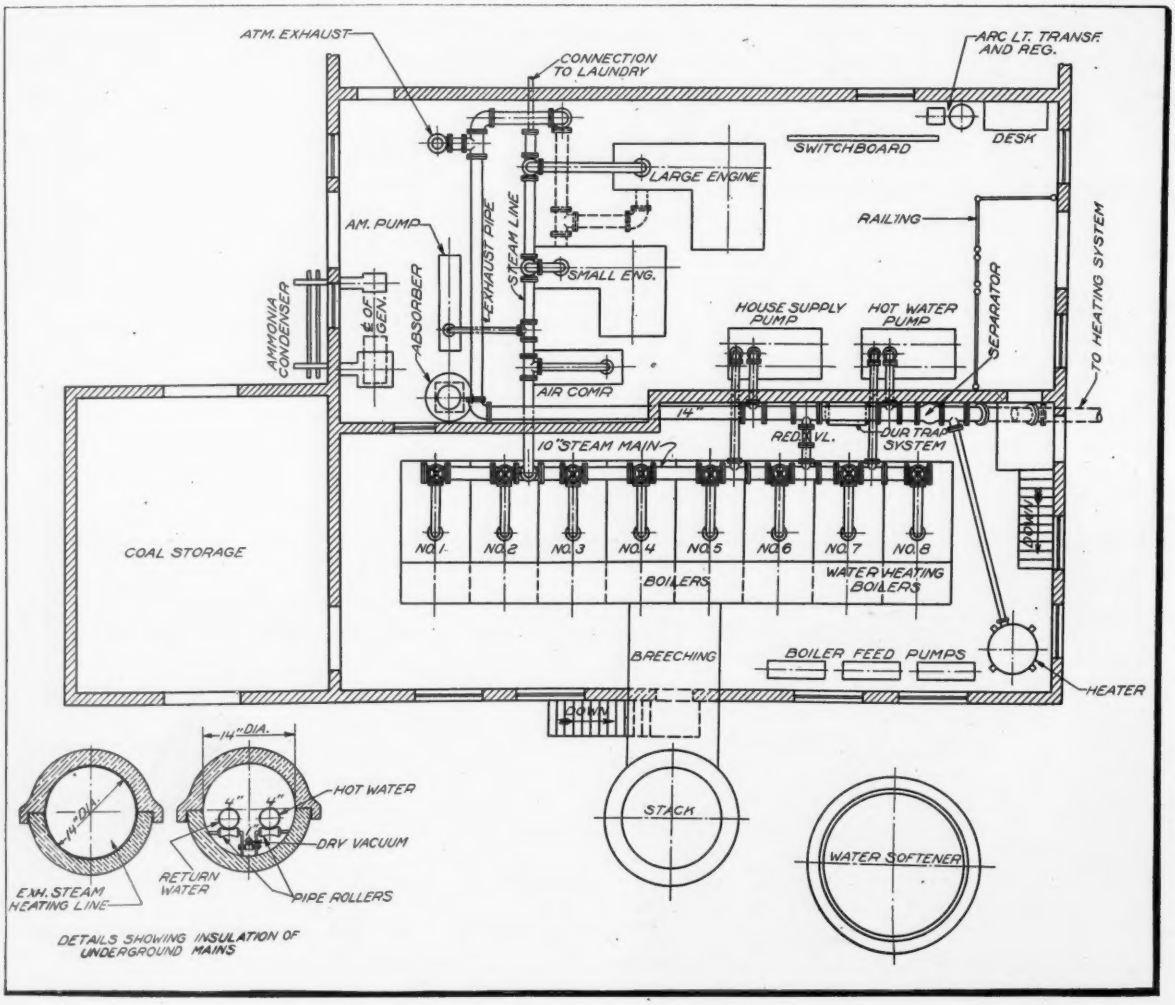


FIG. 2. GENERAL PLAN OF THE PLANT AND STEAM PIPING

Steam is carried on the power boilers at 85 lb. pressure and is used at this pressure for engines, pumps and cooking purposes.

The boilers are equipped with Martin shaking grates and Kunkle lockup pop safety valves. In the blowoff lines are placed Lunkenheimer Duro blowoff valves which discharge to a catch basin, thence to the sewer.

During the heating season, the boiler feed water is principally the returns from the radiators, makeup water being from the general supply having been first passed through a softener. The water may enter the boiler either through the blowoff connection or through the front head. For feeding the boilers there are 3 Dean Bros. pumps, one being a duplex, 7 by 4 by 10-in.; the other 2 are simplex, 9 by 8½ by 12-in. and 8 by 6 by 12-in.

Flue gases are conducted by a breeching extending over the front of the entire battery to the stack directly opposite the middle of the battery and built entirely away from the building. A sectional view of this stack, which was built of radial brick, by Alphons Custodis Chimney Construction Co., is shown in Fig. 5. The stack is 7 ft. in diameter by 125 ft. in height, a peculiarity of construction being the division of the firebrick lining into 2 sections, each 20 ft. in height. The second section is supported upon a ledge built in the inner surface of the stack.

Steam is carried to a 10-in. header extending along the rear of the boilers. Leads to the engines and pumps are taken from the top of the header, thus securing dry steam, while the pipe to the cooking coils is taken from the under side of the header and keeps it drained of condensate.

Generating Units

In the engine room are 2 generating units, the larger of which consists of a 22 by 20-in. Fleming-Harrisburg single cylinder 4-valve nonreleasing Corliss valve gear engine direct connected to a 200-kw., 3-phase generator, running at 164 r.p.m., supplying current at 2300 volts

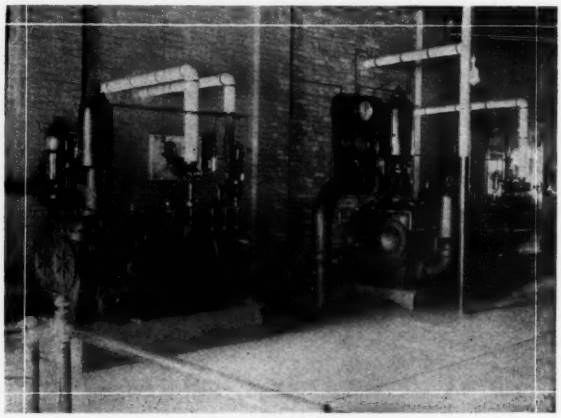


FIG. 3. SERVICE WATER PUMPS

and 60 cycles. The exciter is mounted on the end of the shaft, being compound wound and rated at 10 kw., 125 volts, 80 amp.

The other unit is similar, but smaller, consisting of an 18 by 16-in. engine, a 125-kw. generator running at 200 r.p.m. and an 8-kw. exciter. Wood System electric generators are used. The engines work under an initial

FIG. 4. WATER SOFTENER AND FIRE HOSE HOUSE

pressure of 85 lb. and exhaust to the heating system in the winter and to atmosphere during the warmer seasons.

Control of the electrical output is secured by means of a 7-panel switchboard. Panels Nos. 1 and 2 are similar and are connected to the large and small units, respectively; each is equipped with 3 ammeters, a volt-

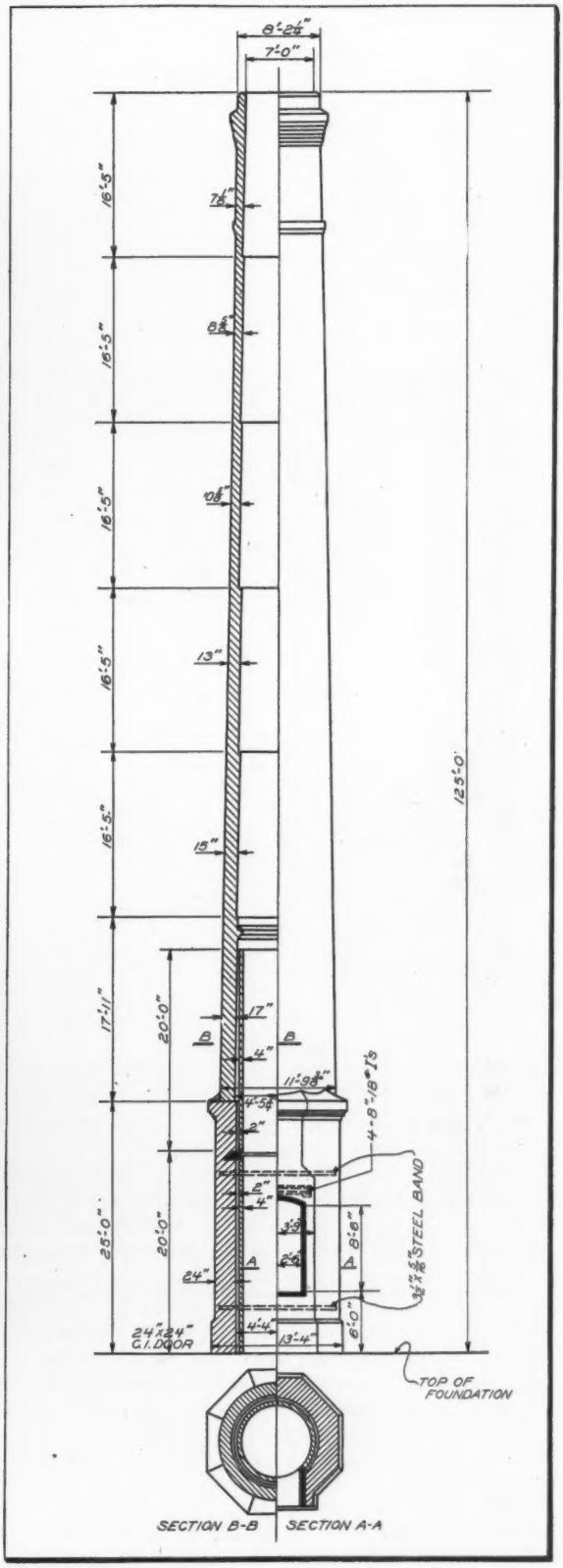


FIG. 5. CROSS-SECTION OF SMOKESTACK

meter, 2 oil switches, rheostat, synchronizing plug and lamps, voltmeter plug and field discharge switch. Panel No. 3 is for controlling the power circuits, Nos. 4, 5 and 6 control the incandescent lighting circuit, and No. 7, the arc lights.

Wiring of the switchboard is such that the power load may be balanced with the lighting load, thus keeping the phases of the generators balanced to operate under most favorable conditions. All lines leaving the power house are carried at 2300 volts, the voltage being transformed down at each building to 110 volts for lighting and 220 volts for power.

At the farm, which is 2½ mi. away, electricity is used for lighting, running feed choppers, wood saws, air compressor and brick-yard machinery. An idea of the diversity of the service of this power plant may be had, not only from the farm machinery which it operates, but also from the machinery at the main institute. In the laundry are 8 tubs, 3 extractors, a mangle, and 50 electric irons; in the Industrial Building are rip saws, planers, band saws, jointers, emery wheels, and lathes; in the shoe shop are sewing machines, buffers, etc.; in the bake shop are dough mixers, bread machines, bread molds and cookie machines; in the cold storage are meat choppers and brine-circulating pumps; in the Sunset Building are 2 80-in. fans used in the heating and ventilating system; all buildings are furnished with light. Lights are all on single-phase circuits, while the motors are all 3-phase, and the plant gives continuous service.

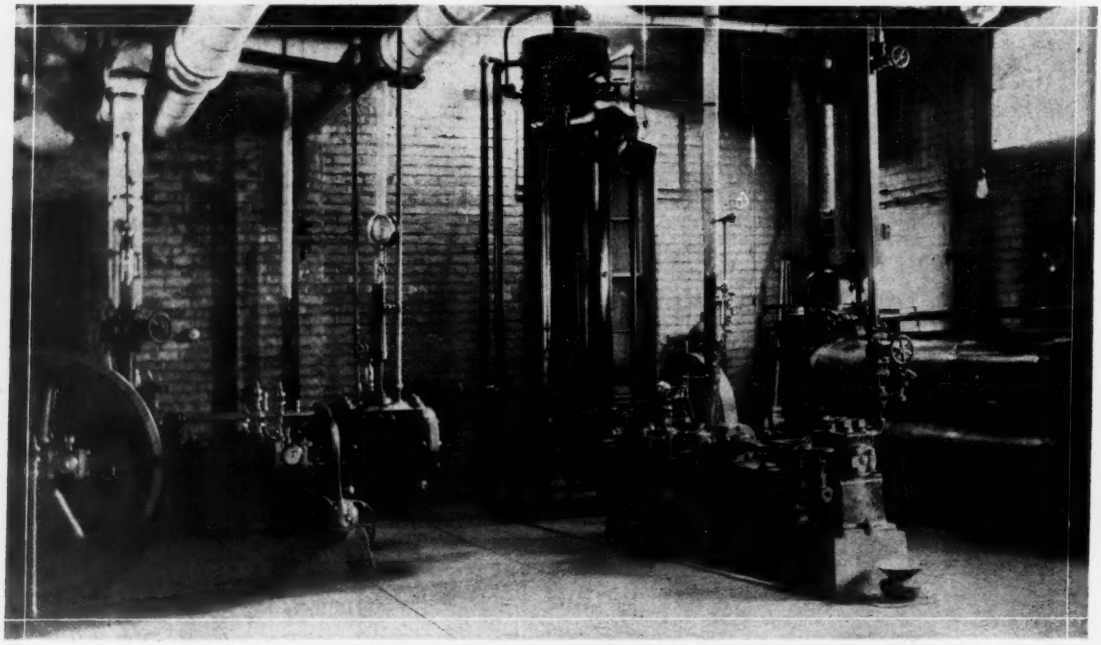


FIG. 6. AIR COMPRESSOR AND REFRIGERATING MACHINERY IN ENGINE ROOM

Water Supply

One of the interesting features of the plant is the water supply system. The source of water is wells, 226 ft. deep, from which water is drawn by the air-lift system of pumping, compressed air being furnished by an Ingersoll-Sargent compressor located in the engine room. Water is delivered to a cistern, which will be increased in size to 25 by 50 by 150 ft., and from here a compound Gardner duplex pump, 10 by 6 by 8½ by 12 in., delivers it through mains to the various buildings, in some of which large tanks are placed in the attics to reserve the supply, while in other buildings the pressure is direct.

For fire protection, 36 hydrants are located in most convenient places about the grounds. Each hydrant has 1 steamer and 2 hose connections, and all are connected to 8-in. water mains circuiting the grounds. Two hose carts, each with 250 ft. of hose, are kept in a separate building, shown in Fig. 4, besides hose stands and patent fire extinguishers in each building.

An analysis of the well water shows it to contain the following impurities:

Silicon	0.06 gr. per gal.
Calcium carbonate	20.86 gr. per gal.
Calcium sulphate	2.03 gr. per gal.
Magnesium sulphate	8.58 gr. per gal.
Suspended matter	Trace
Solids	31.53
Lb. incrusting solids per 1000 gal.	4.5
Sodium sulphate	9.92 gr. per gal.
Sodium chloride	2.51 gr. per gal.
Total solids	43.92 gr. per gal.

Hardness equivalent to 27.58 gr. calcium carbonate per gallon.

Alkalinity equivalent to 21.87 gr. calcium carbonate per gallon.

Part of this water is put through a Northern water softener, which has a capacity of 15,000 gal. per hr., and is then used for domestic purposes and feeding the boilers.

To heat the necessary amount of domestic water, 2 high-pressure boilers are employed, the water being

passed through them with an 8 by 8 by 10-in. Gardner duplex pump placed in the engine room, thence over the grounds through insulated pipe to each building all in one circuit, the steam laundry, each kitchen, scullery and bathroom being supplied with hot and cold soft water and drinking water. The pressure is carried direct upon the system by the pump at 40 lb. per sq. in.

As was stated, the steam boilers are fed with soft water which, during the summer, is passed through a Bass open feed-water heater, rated for 1000 hp., and in cold weather the heating returns are delivered to the boilers by a duplex system of Morehead tilting return

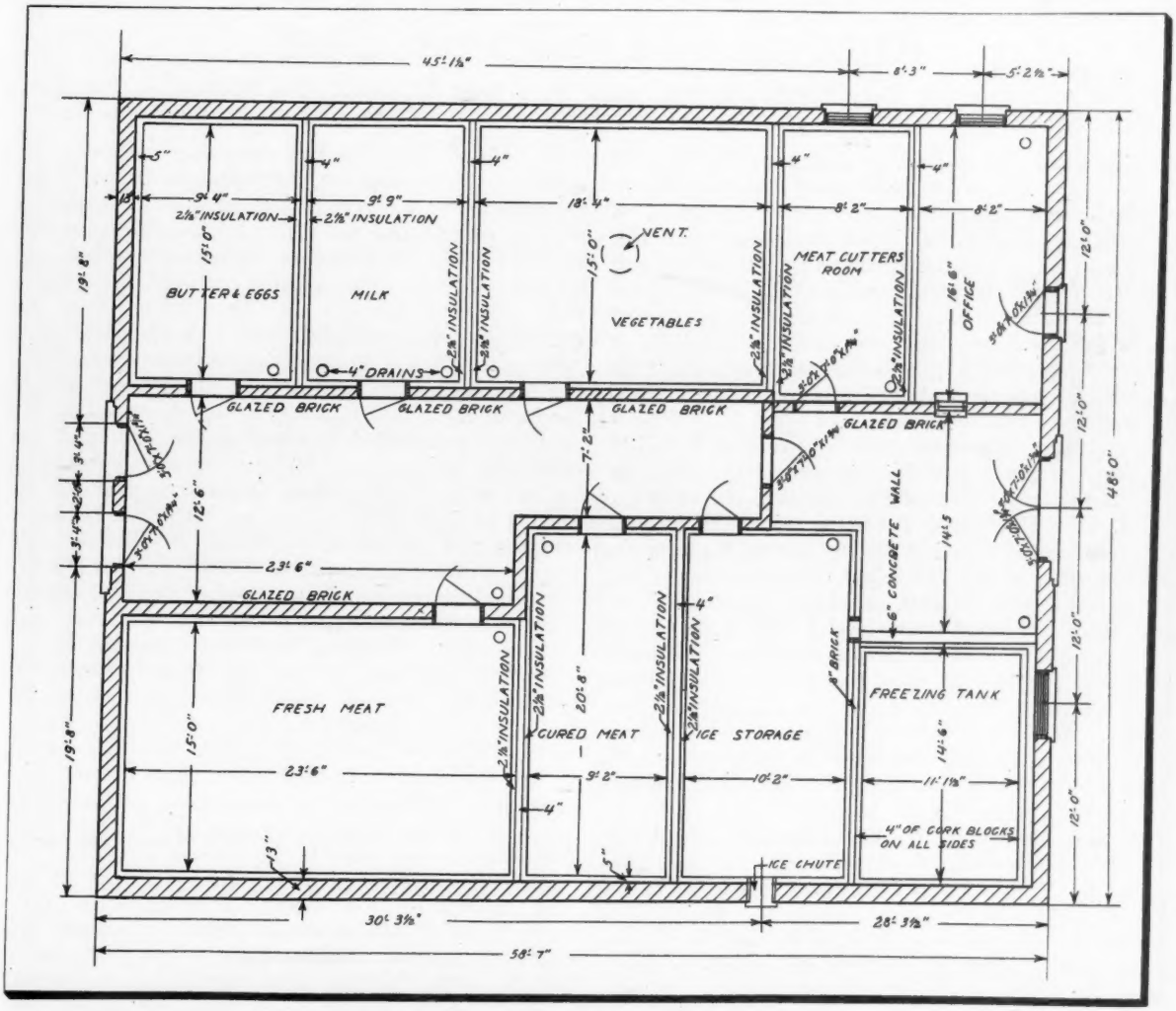


FIG. 7. PLAN OF THE COLD STORAGE HOUSE

vacuum and condenser traps. In addition to the traps, there are 2 Dean Bros. pumps for taking care of return water in case the trap system should fail. A National vacuum pump, 5 by 6 by 10 in., and an injector are also used in connection with the heating system. Makeup water is taken from the soft water supply during the heating season.

Heating System

All exhaust steam from engines, pumps and cooking system is passed through a Cochrane oil-separator, then used in the heating lines. Live steam may be fed into the heating system through an 8-in., 2-way Fisher reducing valve in a pipe connecting the 10-in. main steam header with a 14-in. exhaust header, which distributes the steam as desired to the various buildings.

Several different kinds of heating systems are employed, these are the Warren Webster, Van Auken, Paul and Morgan Clark vacuum, and direct and direct-indirect one-pipe gravity systems, supplying in all about 150,000 sq. ft. of radiation, which is distributed in the different buildings, the farthest of which is about 2000 ft. from the power plant. The pressure carried on the heating main varies from 2 lb., in the coldest weather, down. The dry vacuum returns, hot water piping and return water piping are run from building to building beside each other in trenches. Insulation for the steam and hot-water piping was furnished by the Ric.-Wil. Co.

Ice and Refrigeration

One of the principal services which this plant performs is that of supplying the institution with ice and refrigeration. A 15-ton absorption ice machine, made by Henry Vogt Machine Co., is used for this purpose.

The generator, absorber, condensers and pump are all placed in the engine room, while the expansion coils are placed in the cold storage house about 200 ft. distant. In this house is a freezing tank of sufficient capacity to supply all ice needed by the institution. Water used for ice is taken from the soft water supply and frozen in cans. There are 6 cold storage rooms which are cooled by brine coils, circulation through which is kept up by means of a 5-hp. motor.

In this cold storage house all meats, lard, butter, eggs, milk, etc., are kept until called for by the various buildings. This arrangement does away with a cold storage of large size in each building.

It has been the aim of the directors to make the institution as nearly self-supporting as possible and by establishing a number of industries their efforts have met with noteworthy success. All machinery about the institute is kept in working order by the engineering force, of which Lew L. De Haven is chief, to whom we are indebted for information and courtesies extended in the preparation of this article.

Running on Continuous Test

WEIGHING THE COAL FOR EACH BOILER AND THE STEAM FLOW FROM IT; CONTINUOUS RECORDS OF PERFORMANCE FROM COAL PILE TO SWITCHBOARD; USING THE SUPERHEATER AS AN ECONOMIZER TO ABSORB EXCESS HEAT

IN the plant of the Railway Exchange Building, of St. Louis, are to be found several novel features which are worth more than passing attention, as they show careful study of the conditions to be met and a solution of peculiar problems with ingenuity and understanding. The plant is part of the system of the Power Development Co., which operates a number of plants for furnishing light and power to buildings in the business section of St. Louis, and is located in the basement of the storage building across the street from the Railway Exchange Block.

To give an idea of the load to be carried, it will be necessary to give a few dry statistics about the Block. This is the largest building in the city, if not in the world, having 1,360,000 sq. ft., or about 30 acres of floor space, and covering an entire city block to the height of 21 stories. The height from basement to roof top is 308 ft., the caissons, of which there are 110, extending 70 ft. below street level to bed rock. Seven lower floors and basement are occupied by the Famous and Barr department store, the remaining 14 stories being used for offices, of which there are 105 to a floor, unless divided specially to suit the needs of the tenants. The power plant and warehouse building is located a block north, and is connected with the main building by an 18-ft. tunnel at the basement level. There are 17 miles of elevator cable, which travel 800 miles a day; 130 miles of electric wires; 12 miles of steam and water pipe, and 14,525 automatic sprinkler heads, so that it is evident that at least some engineering was required in the planning, and some more is required in the running of the mechanical plant for the supply of power, light and heat.

Our main interest is in the modern equipment of instruments for measurement and record of the supply and use of energy; but, before passing to that feature, it will be interesting to look over the plant and the service that it renders. The room in which the plant is installed is high enough to allow the placing of the boilers and piping in convenient arrangement, but admits of no waste. There is plenty of floor space, so that ample working room is allowed around the machines; but there is no waste, for the plant will grow, and there will be no chance to get added room in the future. Coal comes by teams to a bunker beneath the sidewalk, so the boilers are set at the street end of the plant with the elevating and conveying machinery between the boilers and the coal bunkers. The turbines are placed near the rear of boilers, and heater, pumps and hot-water tanks are placed on a gallery between the boilers and the turbines. Switchboard, transformers and rotaries are placed at the other end of the room, which has no divisions, a large space being left in the middle for future extensions and, it is rumored, for a possible installation of Diesel engines to carry the electric load during the months when steam is not needed for heating.

Steam is supplied for heating the buildings, for cooking in the restaurant and hot water for house service in restaurant and toilets. Exhaust is used for the heating of both building and hot water, as far as it will go, and the extra demand is supplied by live steam. Current is furnished at 240 volts, a.c., direct from the turbo-generator units, and is used for constant speed motors; transformed to 110 volts, a.c., it is used for the lights. Exciters furnish d.c. current at 110 volts, which is used for small motors and remote control switches; through transformers and rotaries, the 240-volt a.c. is changed to 240-volt d.c. for elevator motors and other uses where variable speed is required.

The switchboard is in 2 parts, that in front controlling the generators, the rotaries and the motors in the plant which operate pumps, fans and conveyor drive. The back section controls the circuits throughout the buildings, and handles all the different kinds of current mentioned. For emergency in which the plant might have to be shut down—which, by the way, has not happened yet, although the resources of the superintendent, Mr. Billings, have sometimes been severely taxed,—there is connection through transformers and disconnecting switches to the 5000-volt lines of the Laclede Light and Power Co., delivering to the 240-volt a.c. buses.

For the 3 rotaries which have a capacity of 1200 amp. each at 250 volts on the d.c. side, the transformers take a.c. current at 250 volts and deliver at 158 volts; the rated capacity is 115 kva. A panel is provided for the d.c. side of each rotary to control the output and the field, and a single panel serves to care for the a.c. side of all 3 rotaries.

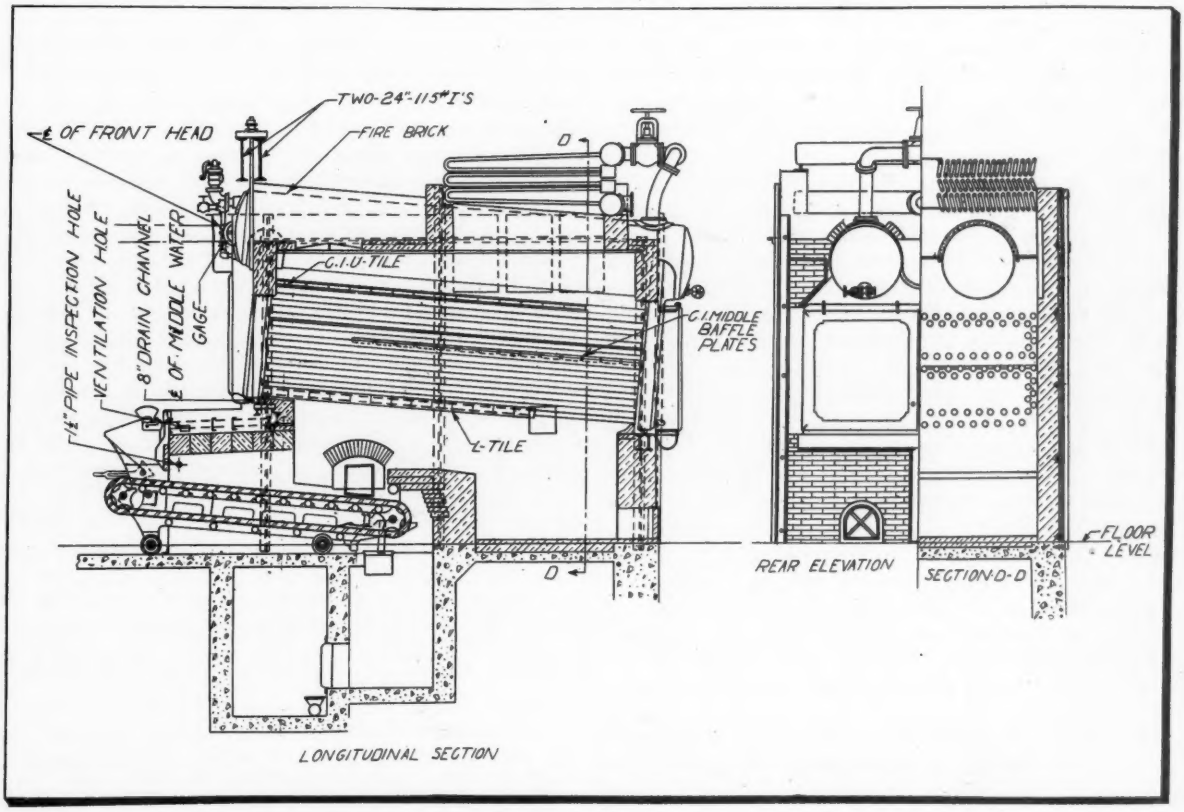
Three Curtis steam turbines form the prime mover equipment, driving direct 750-kw. generators, which

supply 3-phase current at 250 volts, and 60 cycles and running at 3600 r.p.m. Each generator has a controlling panel on the switchboard. Exciting current comes either from a 25-kw. generator driven by a Curtis horizontal turbine, or from a similar generator driven by a 250-volt induction motor, these units having a separate panel on the switchboard.

For the 110-volt a.c. supply, there is an auto-transformer with 3-phase connections and a neutral wire, connected between the 250-volt buses on the front board and the 110-volt a.c. buses on the rear board. The 240-volt current for motors is supplied from the left-hand end of the rear section and the 110-volt circuits from the right-hand end.

the hoppers of the stokers; but, in the usual run of the plant, the bucket conveyor takes it above the boilers where a screw conveyor for each boiler carries it across to the hopper of an Avery scale which, for each filling, records the amount on a chart in front of the boiler and in sight of the fireman. From the hopper, the coal falls by gravity to the hopper of the Green chain grate stoker.

Stoker drive is from either of a pair of vertical engines mounted on the wall of the coal bunker and belted to a countershaft above the boilers. The conveyor drive for the bucket system is a motor mounted at the end of the boiler room on the floor level, and for the screw conveyors by a motor driving a countershaft



SETTING OF HEINE BOILERS IN RAILWAY EXCHANGE BUILDING, ST. LOUIS

With this general survey of the plant, let us see what provision has been made for keeping track of its performance. There is, of course, the usual provision of instruments on the switchboard for keeping record of the output of the generators, of the plant, and on the different circuits. Also the voltmeters and ammeters to show what each piece of apparatus is doing at any moment. The steam end of the plant has, however, quite as complete provision for watching the actions of each unit, and for knowing what return is being made for the heating energy expended.

As already mentioned, the coal, Illinois screenings, delivered in wagons, is dumped into bunkers below the sidewalk, and from these comes through chutes to the elevating system. For emergency feeding, the coal may be delivered to the boiler room floor and shoveled into

which runs the length of the boiler fronts and is connected to the screw shafts by a clutch for each boiler. By this equipment, the amount of coal furnished to each boiler is accurately weighed and recorded, and the totals can be compared with the weights of the coal furnished to the plant. Ashes are removed by a Green Engineering Co. system below the boilers.

On the steam outlet to each boiler is a General Electric indicating flow meter which shows the rate in thousands of pounds of steam per hour at which the boiler is delivering at any moment. Readings are taken every 15 min. and recorded for comparison with the record of the recording and integrating meters which are installed on the live steam line to the building, and on the main which supplies the turbines; this last, which is of the roll record type, can be connected into the main for

any one of the turbines as may be desired, so that the steam consumption per kilowatt of output for different loads can be determined, and a curve prepared which will enable the steam supply to be known from the readings of the switchboard instruments. The meter on the live steam supply to the building is of the indicating, recording and integrating type, and can, of course, be connected into any main by changing the nozzle and using the proper constant for that size of pipe.

Condensation from the building, both for the low-pressure steam on the heating system and from the high-pressure service, is returned to the Cochrane open heater by pumps located at one side of the room, and is measured by a Lea V-notch recording meter incorporated as part of the heater and furnished by the Harrison Safety Boiler Works.

By this equipment, the water going to the boilers is known, and also the steam furnished by each boiler and to each turbine, so that the performance of each unit can be watched and compared with its previous performance.

To keep track of other data needed for studying the work of the plant, there are instruments at each turbine to show the steam pressure and the percentage by which the speed of the unit is slow or fast of that needed to keep the frequency at 60 cycles. There is a Bristol recording gage for the boiler pressure and Bristol recording voltmeters on the a.c. and d.c. lines. And there are the usual integrating wattmeters on feeder circuits and on generator leads. Draft gages on the uptake from each boiler enable the control of the draft in accordance with the steam output and the fire depth.

The boilers and their setting are examples of a maximum of power in a minimum of space. Four Heine boilers of 500 rated hp. each are set in 2 batteries, the outside walls being all fire brick, 13½ in. thick, and the center walls 18 in. thick to economize space. As it was desired to take the steam from the rear of the boilers, and there was not sufficient head room to carry the pipes above the boilers, the steam nozzles are attached to the rear of the drums, and the steam is taken to them from the front ends of the drums through inside steam pipes and steam pots. From the nozzles the steam passes through a stop valve to the Foster bare pipe superheaters which are placed in the uptake from the boiler to absorb heat from the escaping gases. From the superheater, the steam passes through a Crane non-return stop valve to the header which runs across the tops of the boilers and is so connected that steam may be taken from a boiler direct to the turbine that stands opposite it, or fed into the header and carried to any supply main.

The setting of the boilers is of 2-pass type with long igniting arch, the furnace roof being L tile, the middle baffle cast iron and the upper baffle of U tile. Normal rating would call for about 15,000 lb. of steam delivered an hour, but a frequent performance is 35,000 lb., and 24,000 lb. is almost regular, so that even with the contracted space and 2-pass setting the boilers are easily forced to 200 per cent of rating. This is done, too, without much lowering of efficiency, for the flue gas temperature at normal load is about 450 deg. F., and at 24,000 lb. evaporation an hour runs up only to 500 deg. The superheater acts largely as a heat skimmer to take out any excess heat which may be in the gases. At normal load, when the gases are at 450 deg., the superheat will be zero as the steam heat comes from the superheater. When the gas temperature reaches 500 deg., the superheat will rise to 50 deg., and so on, the superheat increasing as the boilers are forced and the gases reach the uptake at higher temperature. Even at heavy over-loads, a draft over the fire of 0.6 in. of water is sufficient to give the highest rate of combustion needed.

Under forced conditions of 200 per cent rating, the amount of CO_2, with the flue gas showing a temperature of 55 deg. in the uptake from the boiler, varies from 11 to 14 per cent, showing a thoroughly good combustion.

Besides the use of steam for the driving of the main generating units and for uses as mentioned in the main building, auxiliary mains are carried to supply the station auxiliary steam-driven units. These are a Curtis steam turbine, driving an exciter which has as an alternate a motor-driven unit, a Westinghouse steam turbine located on the heater gallery, driving a 4-stage Westinghouse centrifugal boiler feed pump, and having as a reserve 2 Westinghouse 40-hp. induction motors, driving Alberger 2-in., 5-stage centrifugal pumps. All these boiler feed pumps take their supply from the Cochrane heater and discharge to the boiler feed line.

Condensate from the heating and live steam supplies is returned through a 3-in. main to the turbine room and pumped to the heater by a Marsh single-cylinder pump, 12 and 22 by 20 in., which has a relay, a plunger pump driven through silent chain and gear by a 25-hp. General Electric induction motor.

Hot water for the house use is supplied by 2 Alberger hot water heaters, taking live steam under control of a temperature regulator for the heating, and having the condensate returned to the feed heater by an Alberger 1½-in. centrifugal pump driven by a 1-hp. motor. The water for these heaters comes from the city mains, and is kept in circulation throughout the buildings by 2 Alberger, 2-in. single-stage pumps, motor driven. For supplying the cold water house service and a fire tank located on the roof, a Lucas triplex pump is installed, driven by a 5-hp. General Electric motor.

The exhaust of the steam auxiliary units passes into the main steam exhaust line and goes to heat the building. Pressure in this line is between zero and 1 lb. gage, and the condensate pumps maintain a 10-in. vacuum on the end of the returns.

POWER PLANT development goes on rapidly in all countries and some are considerably more advanced than the United States in their utilization of resources, even though they may be younger in point of years. In New Zealand an installation of 6000 hp. is about to be put into use, forming part of the Lake Coleridge electric supply scheme, which in its total development will supply about 58,000 hp. The present plant will ultimately give 12,000 hp., which will be distributed among 15 different communities for supplying light, power, and transportation to all the towns in the North Island. Older countries also are adopting electrical improvements, and in Japan the value of electrical properties has jumped during the last 10 yr. from about $14,000,000 to $280,000,000, the power produced advancing from less than 45,000 kw. to 345,000.

Heating and Ventilating Large Buildings

FORCED HOT WATER CIRCULATION; SYSTEMS OF PIPING; RADIATOR CONNECTIONS; SIZE PIPING. BY CHARLES L. HUBBARD

SYSTEMS of heating employed in office buildings may be classed as low-pressure steam, vacuum systems and hot water under forced circulation.

The present article will be devoted to the last of these, giving its principal advantages, as compared with other systems, and data relating to the design, construction and operation of an equipment of this kind. In general, the advantage of a hot-water system over steam is the ease with which the temperature of the building may be regulated, unless the latter is provided with automatic control.

While the back pressure is less with a vacuum system than with hot water, under ordinary conditions, there is no reason why a vacuum pump may not be attached to the heater, practically transforming it into a condenser as well as heater, thus obtaining the advantage of a vacuum system and still retaining a wide variation of temperature in the radiators. Another advantage claimed for vacuum heating is the absence of air valves upon the radiators, all air being drawn out by means of a pump or ejector, according to the system used. Here, again, the same results may be secured with hot water if the piping is suitably installed, as will be described later.

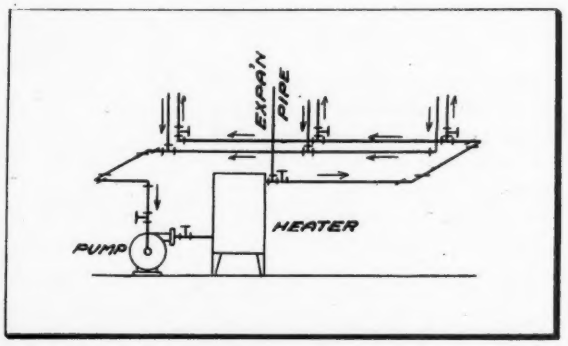


FIG. 1. TWO-PIPE SYSTEM OF FORCED HOT-WATER HEATING

With the heater as ordinarily installed, without a vacuum pump, the back pressure will not exceed that with the engines exhausting to atmosphere, and with a vacuum pump this may be somewhat reduced; no air valves or automatic return valves are required and the temperature of the radiators may be anything desired up to about 240 deg., or the temperature of steam at 10 lb. pressure. All of the mechanical part of the equipment is located in the basement and under the immediate control of the engineer.

If individual temperature regulation is desired in the rooms, it may be secured either by hand valves or automatic regulation, the same as with steam, with the advantage of general control by the engineer, according to outside weather conditions.

GENERAL ARRANGEMENT

THE GENERAL arrangement of the apparatus and the systems of piping commonly employed are shown in diagram in Figs. 1, 2 and 3. In each case a pump is used for forcing the water through the mains, and a heater for raising the temperature of the water by the condensation of either live or exhaust steam.

Figure 1 shows the 2-pipe system, so called. In this case 2 mains are carried around the basement, one for the supply and the other for the return, the former reducing in size as the risers are taken off and the latter increasing as the return drops are connected into it.

As the difference in pressure between these 2 mains is greatest near the pump, regulating valves must be placed in the risers for throttling the flow, in order to prevent short-circuiting and to secure an even distribution through all the radiators in the building. It is usually best to employ lock-shield valves, without handwheels, for this purpose, so that when once set to give the right amount of flow through them they will not be tampered with. While a single valve to each pair of risers is all that is necessary to regulate the quantity of water passing through them, it is usually best to place valves in both the supply riser and return drop, so that they may be cut out from the system in case repairs are necessary to any of the radiators on the line.

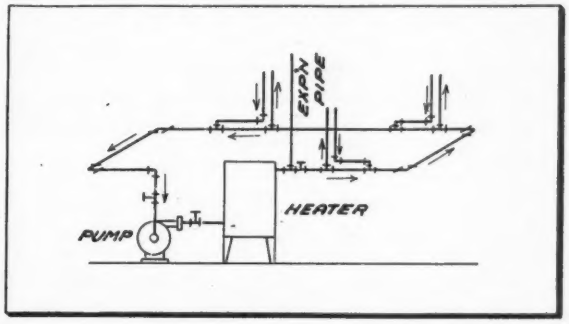


FIG. 2. CIRCUIT SYSTEM OF PIPING

The circuit system of piping is shown in Fig. 2. In this arrangement a single main, of uniform size, is carried entirely around the basement from the pump discharge back to the suction inlet.

It is evident that the pressure in this main drops uniformly throughout the entire length, so that if a supply riser is taken off at any given point and the corresponding return connected into the same main a little farther along, there will be sufficient difference in pressure between the 2 points of connection to produce a circulation through the riser and drop. In addition to this, the flow will be strengthened by the difference in temperature in the supply and return risers, the same as in the ordinary system of gravity circulation.

In practice, the supply risers are taken from the top of the main and the corresponding returns connected

into the side 3 or 4 ft. farther along the line in a direction away from the pump. In both cases an independent expansion pipe is carried either from the heater, or from the main, inside the shut-off valve, to a vented tank located several feet above the highest radiator.

Air valves on the radiators may be omitted in both of these systems of piping if the supply connection is made at the top of the radiator, and the top of each supply riser is vented through ⅛-in. pipe leading to a main connecting with the expansion tank. With this method of piping there will be a continuous upward passage from the highest point in each radiator to the vent in the expansion tank, so that it will be impossible for air to accumulate in any part of the system.

If it is desirable to keep the run-outs to the radiators in the floor space and make both connections at the

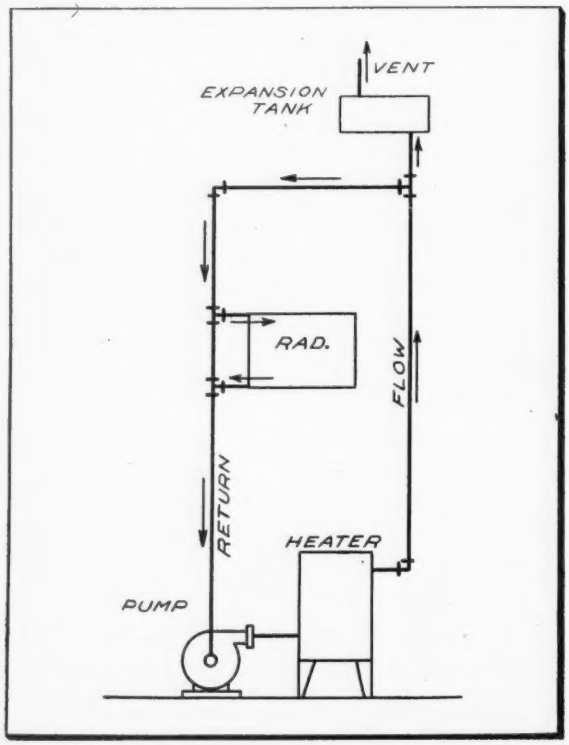


FIG. 3. DIAGRAM OF PIPING, SHOWING RADIATOR CONNECTIONS

bottom, or if the system is already installed in this manner, vent pipes may be taken from the top of each radiator and connected with a main vent leading to the expansion tank.

A desirable system of piping for forced hot-water circulation is shown in diagram in Fig. 3. In this case the main supply riser is carried to the attic, or roof space, where it branches and connects with the various supply drops leading to the radiators. A single drop serves for both supply and return, as indicated in the cut; the hot water enters the top of the radiator and the cooler water is returned into the same drop from the bottom, as shown.

In a system of this kind, the greater part of the air is liberated from the water in the heater and is taken off at once by a pipe leading from the top of the main riser to the expansion tank, which serves both as an expansion pipe and vent. Any further air which may collect in the radiators finds its way upward to the same vent against the flow of water in the piping. The one objection to this system is the cooling of the water as it passes downward to the lower stories, and in tall buildings this must be provided for by increasing the radiating surface a small amount on each succeeding floor downward.

For example: Suppose in a 16-story building the initial temperature of the water at the upper floor is 200 deg., and that it falls to 170 deg. by the time it reaches the lower floor. Suppose also that all of the radiation is first computed for a difference of $200 - 70 = 130$ deg. between the initial water temperature and the room temperature. Under the conditions of the problem this difference will be only $170 - 70 = 100$ deg. on the first floor, and as the efficiency of the radiator is proportional to the difference between its temperature and that of the room, the efficiency of the first floor radiators will be only $100 \div 130 = 0.77$ of that on the upper floor, and the size of the radiators must be made $1.00 \div 0.77 = 1.3$ as great to give off the same amount of heat.

It will not be necessary to make this correction for each separate floor, but say for each 3 or 4 stories. In the present case, after computing the entire radiation of the building on the same basis, we should multiply the surfaces on the first to fourth floors by 1.3; the fifth to eighth by 1.2; and the ninth to twelfth by 1.1. In like manner the correction factors may be obtained for any other set of conditions.

Size of Piping

Size of the piping depends upon the volume of water to be forced through it and the length of run and number of bends. The volume of water, in turn, is fixed by the thermal units to be supplied to the radiators and the drop in temperature between the discharge and suction of the pump. One gallon of water in cooling 1 deg. will give out 8.3 B.t.u. and it is usual in this class of work to count on a drop of 30 to 40 deg. between the supply and return. Taking the lower figure, each gallon of water circulated will give out $8.3 \times 30 = 249$, or, in round numbers, 250 B.t.u.

For the average conditions of forced circulation we may count on an efficiency of about 190 B.t.u. per sq. ft. of direct radiation per hour, and 1150 B.t.u. for blast coils when used in connection with a fan. This calls for $190 \div 250 = 0.76$ gal. of water per hour for each square foot of direct radiation, and $1150 \div 250 = 4.6$ gal. per sq. ft. for hot-blast coils.

In determining the heating surface in a building to be supplied with hot water, we should increase the result about 20 per cent for losses from piping and as a factor of safety.

Example: A building contains 10,000 sq. ft. of direct radiating surface and 2000 of hot-blast coils; how many gallons of water should be circulated per minute?

$$(10{,}000 \times 0.76) + (2000 \times 4.6) = 16{,}800, \text{ and}$$

$$\frac{16{,}800 \times 1.2}{60} = 336 \text{ gal. per min.}$$

The size of the main is fixed by the allowable velocity of the flow through it, and the frictional resistance due to its length and number of bends.

In the arrangement shown in Fig. 2, the length of the main and number of bends are easily determined and the size is made the same throughout, as already stated. No allowance is made for the frictional resistance through the risers and radiators as this is practically taken care of by the difference in temperature in the 2 risers, assisted by the drop in pressure in the main between the supply and return connections.

In the 2-pipe system shown in Fig. 1, it is customary to assume that the conditions are the same as though the water flowed through the circuit in a single pipe of uniform size, instead of 2, one of which is constantly increasing and the other decreasing. In other words, the flow main, when it leaves the heater, and the return to the pump, are made equal in size, and the diameter and length are assumed to be the same as in Fig. 2, for duplicate buildings.

In Fig. 3 it is assumed to be the same as though the main were kept of uniform size and first carried to the extreme end of the basement, then to the attic, across to the other end of the building, down to the basement, and back to the pump.

In work of this kind it is usually customary to base the size of main on an assumed velocity which may be taken as 300 ft. per min. for a 3-in. pipe up to 600 ft. for an 8-in. pipe.

The pressure head pumped against is simply that required to overcome the friction in the pipe, as all vertical columns are in equilibrium, except for differences in temperature, which tend to produce a flow rather than retard it.

From a table of hydraulic data referring to the flow of water through pipes of different size, 100 ft. in length, we have the following:

TABLE I

(Mains 100 ft. in length.)

Diameter of Main, Inches	Velocity of Flow, in Feet per Minute	Gallons Discharged per Minute
3	300	110
4	420	275
5	420	428
6	480	705
7	540	1079
8	600	1566

In the average building, the length of main will not usually exceed 1000 ft., which, for the figures given in the above table, will call for pressure heads ranging from 34 to 47 ft.

Ordinarily, the pressure head should not exceed about 60 ft. for the best results with the type of pumping machinery used for this class of work. Simplifying the tables given above, we may say that, for equivalent lengths of main not exceeding 1200 to 1500 ft., the following capacities may be assumed for different diameters of pipe:

Diameter of Pipe, Inches	Gallons per Minute
3	100
4	250
5	400
6	700
7	1000
8	1500

In estimating the resistance due to bends and fittings, the following table may be used:

TABLE II

COMPARATIVE LOSS OF HEAD IN FITTINGS AND STRAIGHT PIPE

Name of Fitting	Number of Feet of Clean, Straight Pipe of Same Size Which Would Cause the Same Loss as Fitting
6-in. Swing Check Valve	50
6-in. Lift Check Valve	200
4-in. Swing Check Valve	25
4-in. Lift Check Valve	130
2½-in. to 8-in. long-turn ells	4
2½-in. to 8-in. short-turn ells	9
3-in. to 8-in. long-turn tees	9
3-in. to 8-in. short-turn tees	17
⅛th bend	5

For groups of buildings where the length of run exceeds 1500 ft., more complete tables should be consulted, which may be found in any engineer's pocketbook on hydraulics, and also in many catalogs of pumping machinery.

The sizes of the supply and return risers between the basement mains and the radiators, in the system shown in Figs. 1 and 2, may be taken from Table III.

TABLE III

Size of Supply and Return Risers, Inches	Square Feet of Direct Radiation Supplied
¾	50
1	100
1¼	200
1½	300
2	600
2½	1200
3	2000

With the upward feed, 2-pipe and circuit systems the risers may be reduced every 2 or 3 stories upward, keeping the sizes just sufficient to supply the radiation above them, which is, of course, constantly diminishing. With the down-supply, single-drop system, shown in Fig. 3, Table III may also be used; but in this case the pipe must be kept the same size for its entire length, and must be proportioned for the total amount of radiation supplied by it.

FREQUENTLY, IN figuring power plant costs, the question arises, what per cent of depreciation should properly be charged off each year on the buildings and the equipment. In a discussion before the American Society of Mechanical Engineers, H. Shuckmann gives as safe values to use: For factory buildings, 5 per cent annually; for power plant equipment, 10 per cent; electric light system, 7 per cent; tools and fixtures, 10 per cent; general construction, such as fences, walls, and so on, 7 per cent; water works, 10 per cent; oil storage tanks, 7 per cent; dwellings, 5 per cent.

Mixing Devices with Hand-Fired Furnaces

OPERATION OF THE STEAM JET. BY H. H. LATIMER

TWO requisites for complete combustion in a boiler furnace are recognized by all authorities:

1. A sufficient amount of air must be admitted.

2. The air must be thoroughly mixed with the furnace gases.

Based on these 2 principles, with the idea of preventing smoke and insuring complete combustion, many inventions have been made. The most common of such devices is the steam jet, which is either automatic in its operation or may be regulated by hand.

As most of the air is required in a furnace at the moment of firing, and the amount diminishes as the volatile matter in the coal is distilled, steam jets require close regulation for good economy. Any steam jet which will mix the air and gases at the time of the greatest need will, if allowed to run continuously, waste more energy than it will save. At the same time such a device will, if properly installed and regulated, keep a clean stack and boiler and save coal.

Figure 1 illustrates one of these devices installed in a furnace under a water-tube boiler. When the furnace

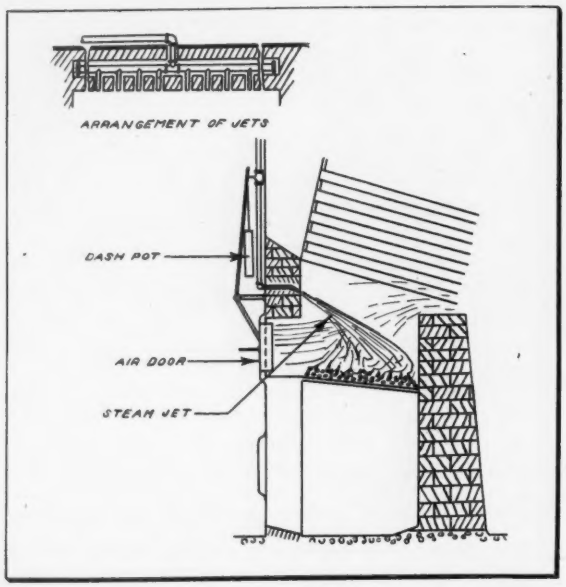


FIG. 1. STEAM JET INSTALLED UNDER A WATER-TUBE BOILER

door is opened, steam is automatically admitted by way of the jets, and air by way of the small door just above the fuel bed. The length of admission of the steam and air is controlled by means of the dashpot.

Figure 2 illustrates a similar automatic steam and air admission device used in connection with the furnace of a return-tubular boiler.

Occasionally, claims are made that the use of a steam jet will increase the thermal value of the coal, meaning that the steam will be broken down into hydrogen and oxygen and that some of the oxygen will be available to burn the coal. This statement is entirely erroneous and should be given no consideration. The same quantity of oxygen that is formed by the dissociation of a pound of steam would be required to burn the hydrogen liberated from the pound of steam; hence, no oxygen would be available from dissociation to burn the coal.

A fact to be remembered is that, in using steam for the purpose of mixing, all of the steam entering the furnace must be heated to stack temperature and that this heat must be supplied from the coal. There is no question as to the value of mixing the air and gases and, if this mixing could be accomplished by some other means than the use of steam, this loss in heat would be avoided. The great difficulty, however, is to build arches and piers capable of withstanding the intense heat and also not to diminish the furnace space.

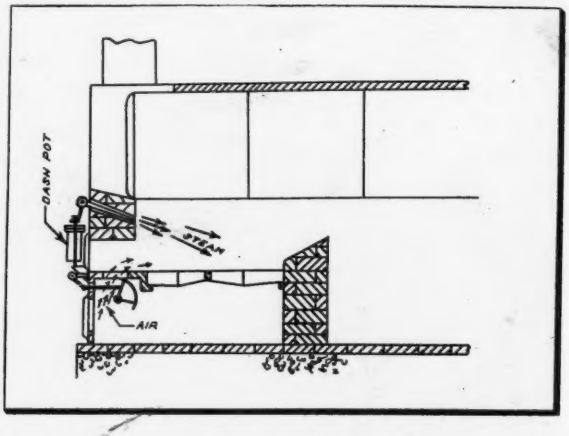


FIG. 2. RETURN-TUBULAR BOILER EQUIPPED WITH STEAM JET

A common method of regulating the air supply in a hand-fired furnace is to leave the furnace door cracked after firing. From a series of tests it has been ascertained that a higher efficiency may be obtained by this method than by using steam and mixing devices; but it is not to be advised, since it introduces the personal element and the supply of air is apt to vary. It is possible by cracking the furnace door in this manner to admit large quantities of air and reduce all visible signs of smoke at the stack, but at the sacrifice of efficiency.

THE WORLD STILL loves a faker. We have bogus mines and bogus land projects and rubber plantations in Mexico, and one of the hardest fields to rid of fakers is that of oil. Worthless oil stock, boomed by promoters who claim the endorsement of the government bureaus, is one of the latest and most barefaced attempts to separate the public from its money. Lands in Wyoming and the "Denver basin" are claimed as oil bearing, whereas, the Government geologists, after careful examination, reported the land as "nonoil," and it was released for homesteading. A request to the U. S. Geological Survey will always bring reliable information in regard to any oil or mineral region, and 2 cents of prevention is worth dollars of cure.

Mercury Vapor Power Plant

PUSHING UP THE TEMPERATURE LIMIT BY USING MERCURY IN A PRIMARY UNIT AND RECLAIMING ITS EXHAUST HEAT FOR A STEAM UNIT

SINCE the first experiment of James Watt, effort has been continuous to improve the economy and efficiency of the heat engine. It was early known that the possible efficiency depended on the temperature range and the upper temperature limit, the limit for theoretical efficiency being $(T_1 - T_2) \div T_1$, in which T_1 is the upper absolute temperature and T_2 the lower. This possible efficiency is modified, first, by available sources of heating and cooling, 2700 deg. F. for the hot gases from burning fuel, and the temperature of the cooling water for condensing; second, by the mechanical difficulties of handling the working medium and the heat transmitting powers of our boiler and condenser surfaces.

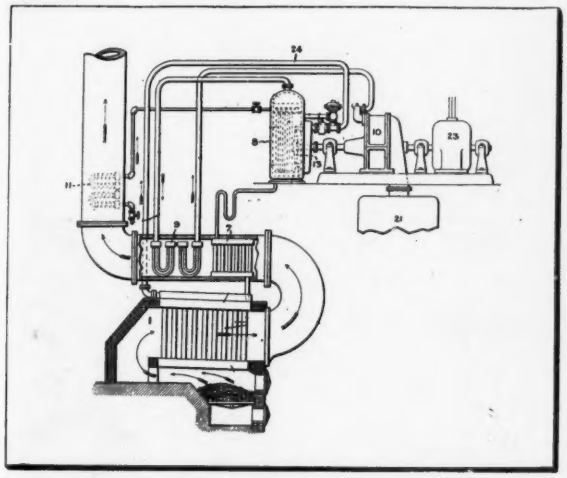


FIG. 1. DIAGRAM OF THE MERCURY VAPOR SYSTEM, 1. MERCURY BOILER. 7. LIQUID MERCURY HEATER. 8. STEAM CONDENSER-BOILER. 9. STEAM SUPERHEATER. 10. STEAM TURBINE. 11. FEED-WATER ECONOMIZER. 13. MERCURY TURBINE. 21. STEAM CONDENSER. 23. ELECTRIC GENERATOR. 24. MERCURY VAPOR PIPE

At 29.5 in. vacuum, the temperature of steam is 56.5 deg. F., and there must be some difference of temperature between steam and cooling water to cause heat transfer, so that, with modern low-pressure turbines, we have gone about as far as possible in the low limit. To get higher steam temperatures, involves high pressures or high superheat, and these involve great expense in boiler construction and difficulties with valves, piping and turbine blades. The natural direction for further effort is, therefore, the use of some other medium than steam, and W. L. R. Emmet of the General Electric Co. has been experimenting with mercury to find what can be done. The work has progressed so far that he has been able, in an article in the General Electric Review and a paper before the Schenectady branch of the A. I. E. E., to give an outline of the possibilities, and to report a 100-hp. plant soon to be tested out.

Advantages of the method as stated by him are: 1. High boiling point of mercury for low pressures; the temperature is 667 deg. F. for atmosphere and 445 deg. F. for 28 in. vacuum, so that the exhaust mercury vapor has higher temperature than that of initial steam in ordinary practice. 2. Low specific heat; 0.0373 for the liquid and 0.0248 for the gas. 3. High specific gravity, and density, 6.56 times that of steam at atmospheric pressure, which permits gravity feed to the boiler, gravity sealing of valve stems, centrifugal sealing of turbine packings and carrying of large amount of power for small volume of vapor, and permits the use of short

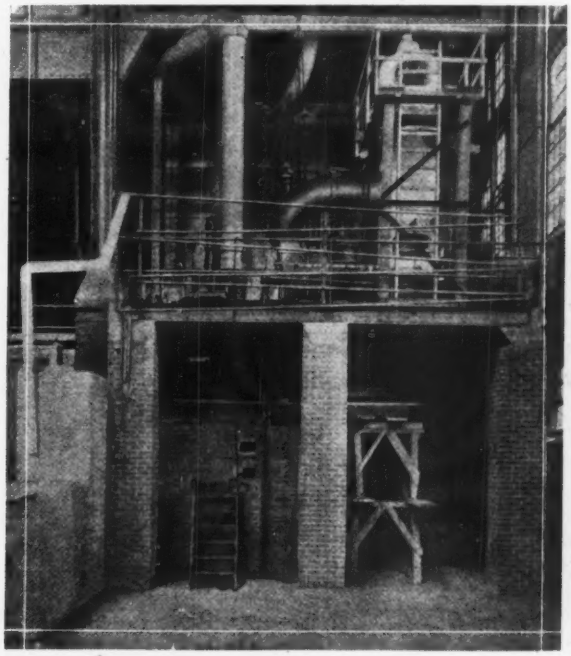


FIG. 3. EXPERIMENTAL MERCURY BOILER AND TURBINE PLANT

turbine blades and small exhaust area. 4. Low spouting velocity, about 1200 ft. a second, permitting low velocity of turbine blades and a single wheel. 5. No impurities carried and no tendency to combine with air, water or iron, so that there will be no scaling or corrosion of boiler surfaces, no erosion of turbine blades, and no deterioration of the working medium. 6. Rapid transfer of heat to water in the condenser-boiler, the rate being 8 hp. per sq. in. of heating surface in steam boilers at a difference of 1100 deg. F. and 24 hp. per sq. in. in a condenser at 20 deg. difference. The condenser-boiler works under the same conditions as a steam condenser.

Disadvantages of mercury are that it costs 60 cents a pound and requires investment of about $7.50 per hp. for working fluid. The vapor is poisonous, and both liquid and vapor are hard to confine, requiring special precautions at all points.

The general scheme, as shown in Fig. 1, is to evaporate the mercury in a special boiler at a little above

atmospheric pressure. This will require small expenditure of heat per pound, as the latent heat is 117 B.t.u. for 25 lb. absolute pressure, 118 B.t.u. for 15 lb., 121 B.t.u. for 28 in. vacuum. The vapor is passed through a single wheel turbine and exhausted into 28 in. vacuum, passing to a water-tube steam condenser-boiler, where the mercury vapor condenses on the tubes and makes steam at 175 lb. pressure and 150 deg. superheat for use in an ordinary steam turbine.

As the gases will leave the mercury boiler at high temperature, they will be passed through a liquid mercury heater, raising the mercury almost to boiling point, then through a steam superheater, and finally through an economizer to heat the feed water, being passed to the stack at about 300 deg. F. The condensed mercury is to flow from the condenser-boiler by gravity through the liquid heater to the boiler, doing away with a feed pump. Surfaces of the mercury boiler and heater will always be clean, and the boiler will be fired the same as a steam boiler. In case the mercury turbine was shut down, the vapor would pass through a safety valve to the steam boiler, and all heat in the mercury vapor would be used in making steam.

Experiments on evaporating mercury showed that a free flow of liquid is needed, and small volume with large heating surface so that vapor is not formed until it can escape into the vapor space; otherwise, there is a tendency for the vapor film to get between the heating surface and the liquid. This has led to the use of flattened tubes, curved to take care of expansion strains, and extending between lower and upper headers as shown in Fig. 2, the headers being joined to the tubes by welded joints and attached to vapor drums by bolted joints, which are surrounded by vacuum boxes to catch any vapor that may escape from leaks, and carry it to a water cooled condenser.

A liquid downtake leads from the vapor drum to the hottest part of the lower header, thus giving greatest supply of liquid at the point where there is the greatest heat transfer.

For the steam boiler-condenser, an ordinary high-pressure feed-water heater is used, although it is probable that some special provision for expansion will be found desirable in later designs.

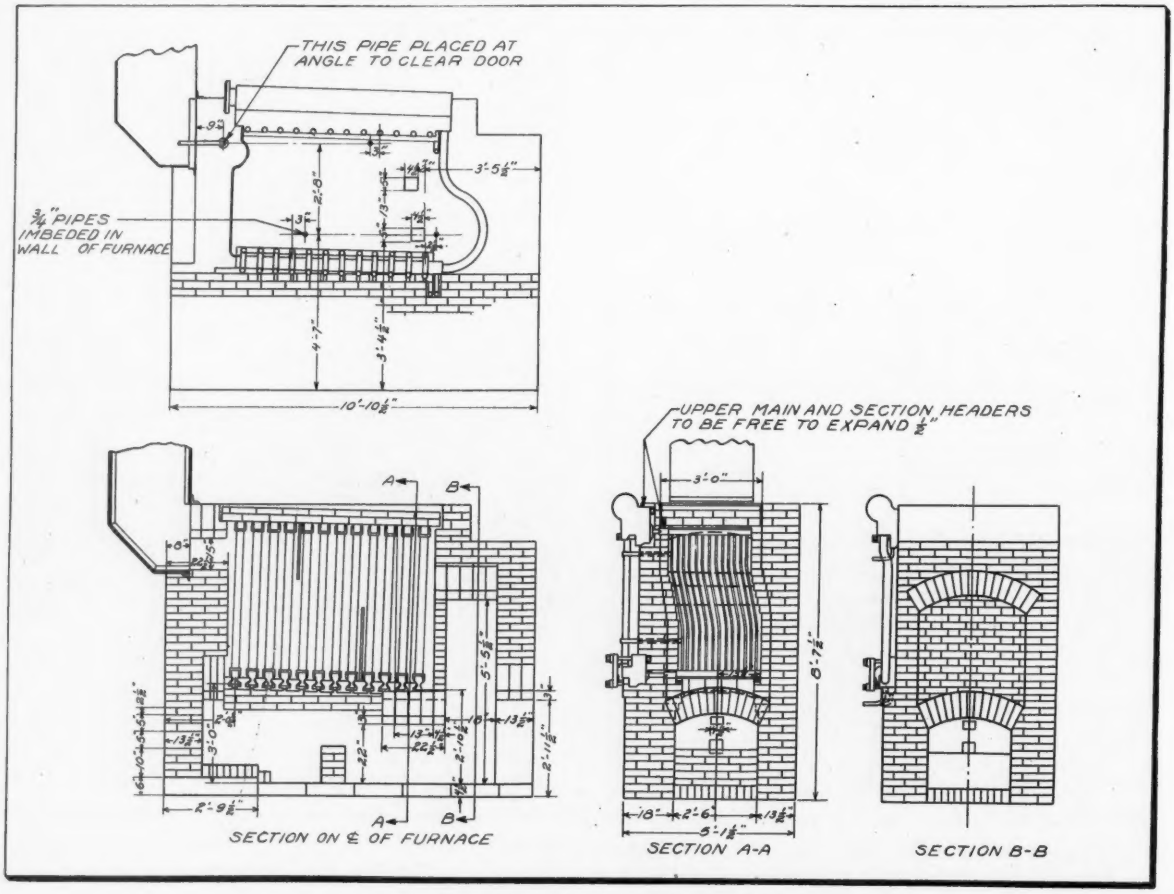

THIS PIPE PLACED AT ANGLE TO CLEAR DOOR
3/4" PIPES IMBEDED IN WALL OF FURNACE
UPPER MAIN AND SECTION HEADERS TO BE FREE TO EXPAND 1/2"
SECTION ON ℄ OF FURNACE
SECTION A-A
SECTION B-B

FIG. 2. MERCURY BOILER AND SETTING

It is estimated that, for existing plants, the added investment for use of mercury will be about the same per horsepower as that for present steam equipment, not including real estate, and that the mercury boiler, steam boiler-condenser, liquid heater, and superheater will take about the same space as present boiler plant. This will give 66 per cent added power, at an added fuel cost of 15 per cent, or a gain of 45 per cent in power per pound of fuel, for a plant operating between 10 lb. gage and 28 in. vacuum on the mercury side, and 175 lb. at 150 deg. superheat and 28 in. vacuum on the steam side.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

Practical Electrical Engineering *

CONSTRUCTION OF SPECIAL TRANSFORMERS AND THEIR USES. BY NORMAN G. MEADE

FIGURE 12 shows the elementary details of a constant-current regulator. One coil is stationary and the other movable, it being balanced against gravity by a counter weight connected to the coil by a rope passing over a sheave. A dash-pot is provided to prevent sudden oscillations of the coil.

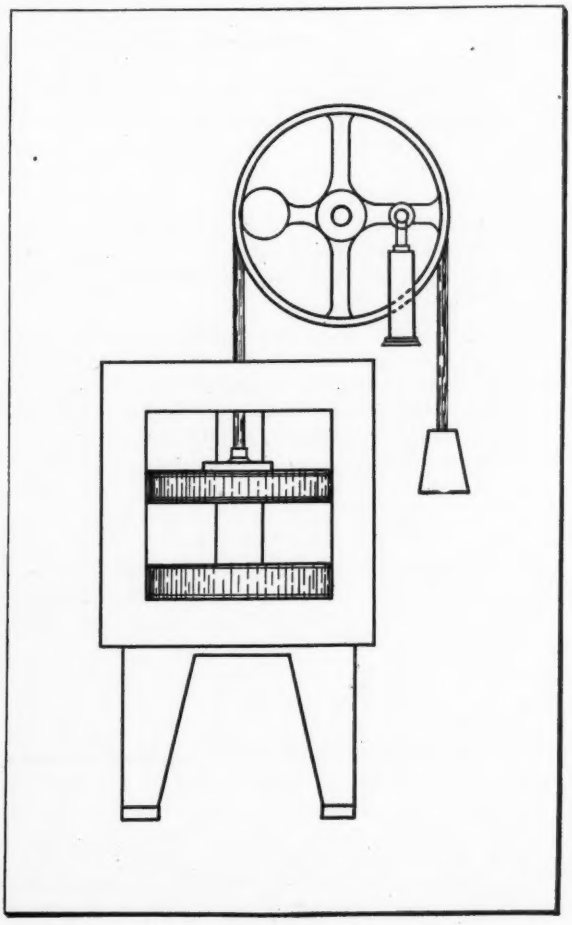


FIG. 12. CONSTANT-CURRENT REGULATOR

The secondary coil has several taps connected to tions in the reactance being obtained by the movement of the coil up and down in its iron shell. If, during operation, the resistance of the delivery circuit is decreased, the delivered current would tend to rise, the coil and core would be drawn more closely, one within the other, and the reactance would be increased to such an extent that the current would be decreased. It is evident that a decrease in current will result.

*Continued from page 494, May 1 issue.

PIPE THAWING AND WELDING TRANSFORMERS

THESE TYPES of transformers are built for a very small secondary voltage and high current value. In Fig. 13, P is the primary winding and S the secondary winding consisting of a single loop of heavy copper, and C is the iron.

REGULATING TRANSFORMERS AND INDUCTION REGULATORS

FIGURE 14 shows the connections of a single-phase regulator which consists of a transformer whose secondary coil is connected in series with the line and the primary coil connected across the line.

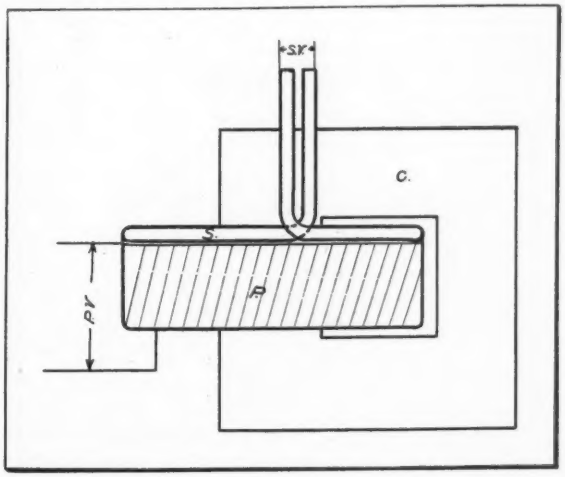


FIG. 13. PIPE THAWING TRANSFORMER

The secondary coil has several taps connected to contacts and by means of a switch lever the secondary voltage can be added to that of the line, the value being determined by the number of turns connected in circuit through the medium of the switch.

Figure 15 shows the connections of an induction type regulator for single-phase circuits; it consists essentially of a transformer having a movable primary coil so arranged that any desired portion of the magnetic flux set up by the coil may be made to pass through the

secondary coil. The magnetic flux of the 2 coils may coincide with or be opposed to each other. A stationary cylindrical shell or core has 2 inwardly projecting poles on which are placed the 2 secondary coils connected in series with the feeder circuit to be controlled. A movable cylindrical core is arranged so that it can be turned through an arc of 180 deg. between the 2 poles on which the secondary coils are wound.

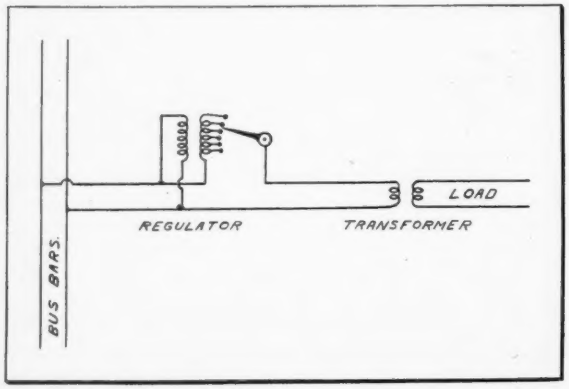


FIG. 14. CONNECTIONS OF SINGLE-PHASE REGULATOR

The relative angle between the normal position of the rotor and any given position, determines the relative effective regulation. In other words, the voltage generated in the secondary varies with the mechanical position of the rotor, but the voltage at all times remains directly in time phase with, or in time phase opposed to the primary electromotive force. Thus, the resultant

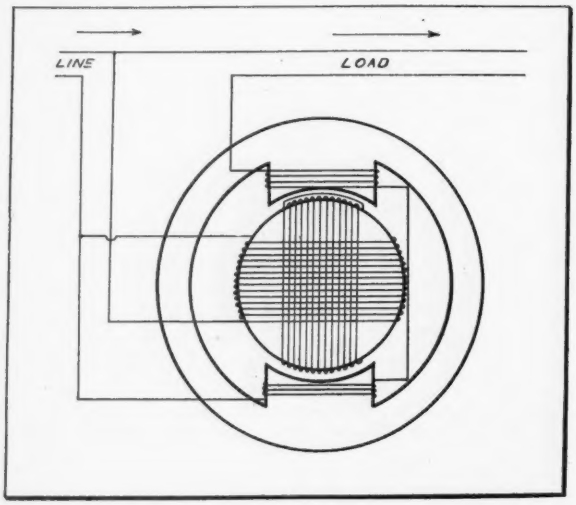


FIG. 15. CONNECTIONS OF INDUCTION TYPE REGULATOR

delivered electromotive force is equal to the arithmetical sum (or difference) of the primary and the secondary electromotive force, the latter depending on the position of the movable element.

When the regulator is in use, even when the secondary electromotive force is zero value, the secondary current may have full value, because it depends solely upon the delivered electromotive force, and the impedance of the delivery circuit. With the moving members in certain positions, the magneto-motive force of the secondary current would be opposed in no respect by the primary current, so that a large value of flux would tend to interlink with the secondary coil and produce an enormous resistance therein. To overcome this defect there is placed upon the primary core in electrical space quadrature with the primary coil, a separately insulated coil which is electrically closed and forms a short-circuited secondary to the real secondary coil of the regulator which acts as the real primary coil.

Polyphase induction regulators are similar in construction to the single-phase regulators with the exception that there are 2 shunt coils for a 2-phase system and 3 shunt coils for a 3-phase system.

Synchronous Motors for Driving Large Air Compressors

By H. L. Dean

CENTRAL power stations and the economical transmission of electrical current at high voltages have greatly increased the general sphere of usefulness of electric motors, but in no field has the superiority of motor drive been more pronounced than in that involving large air or gas compressors. Experience has so conclusively proven that cost of operation may be greatly reduced through the replacement of even the most efficient Corliss engine-driven compressors by motor-driven units, that such replacements are rapidly made in railway shops, industrial plants, mines and on large contract work.

The highest type of power-driven air compressors yet developed and perfected is that in which the motor or armature of the driving motor is mounted directly on the crank shaft of the compressor and, as this type of machine, which is comparatively new, permits the employment of synchronous motors, the writer wishes to point out a few characteristics of these, which may not be evident to or considered by the majority of engineers.

Synchronous motors for air compressor service being modifications of slow speed engine-driven alternators, and consequently very efficient and capable of operating at unity power factor, are far preferable to induction motors, the latter having especially lower power factors and relatively low efficiencies when constructed with a large number of poles to operate at slow speeds. The starting of large induction motors from a line of already low power factor, often causes such a drop in voltage that other motors on the line will fall out of step, thereby producing oscillations and disturbances that affect the entire line and consequently central station regulation.

Such conditions are eliminated through the use of the synchronous motor, for while this motor operates normally at 100 per cent power factor, it may be operated efficiently with a leading current and thus counteract part of the lagging load occasioned by a too great preponderance of induction motors on the line. Engineers will appreciate from this statement that, for best results, a synchronous motor should be designed espe-

cially for the conditions to be met and these conditions should be carefully investigated and submitted to the motor manufacturers. The operation of an air compressor is such that no overload can be obtained; the conditions in this case permit the employment of a motor for operating at a leading power factor and such a motor can be obtained at slight additional expense.

One point should be clearly understood, however, and that is, the power factor of the synchronous motor being under the control of the operator and thus permitting of being made unity, leading or lagging by adjustment of the field rheostat, introduces a condition where it is entirely possible to obtain a poorer power factor with a synchronous motor than is inherent in the design of the induction type. Emphasis should therefore be laid on the necessity of placing synchronous motors in the hands of competent and responsible attendants.

The starting characteristics of the synchronous and squirrel cage induction motors do not differ materially in that each draws a heavy line current if started under load and the starting apparatus is similar for each. Air compressors are customarily provided with bypass valves to relieve the load during the starting period and synchronous motors for such service are made self starting through the employment of a comparatively high resistance squirrel cage winding placed in the pole pieces and connected to a continuous short-circuiting ring around the motor.

This winding also acts as a damper to lessen the effects of hunting, but should not have too high resistance or the pull in torque will not be sufficient to have the motor come into synchronism while on the compensator. The latter is desirable so that the field may be put on the motor while still on the compensator in order to avoid the high magnetizing current due to the large air gap and eliminate the heavy surge of current if the motor is thrown on the line.

Should a synchronous motor fall out of step or break down under load or from loss of voltage, it will not recover if the load is removed; but excitation must also be removed and the motor started in the regular manner. Overloads, as previously noted, are impossible in air compressors and a low voltage release should always be provided in the main line switch.

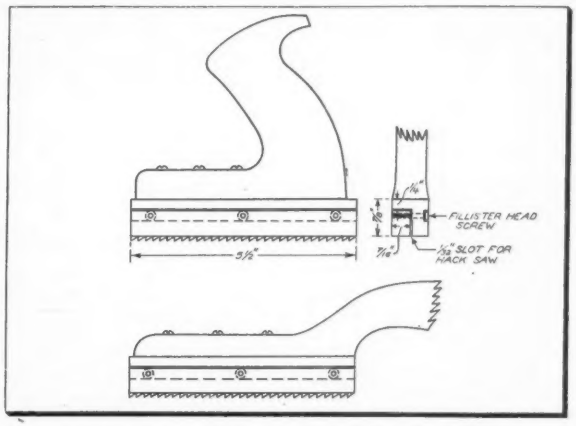
It is obviously out of place to enter into a detailed discussion of those conditions under which induction motors can be advantageously installed; but the broad distinction is that while they are very satisfactory at high speeds, the synchronous motor is far better at slow speeds and a consideration of the points noted, together with the fact that practically all of the air compressor builders of prominence are today recommending synchronous motors for large units, should do much toward overcoming the prejudice of some engineers and enable them to understand the popularity which the synchronous motor in general enjoys.

THE NEW POWER PLANT at Bear Valley (Pa.) colliery is the largest and most modernly equipped in the anthracite coal regions and will furnish power for motors, pumps, fans, hoisting machinery, surface and underground haulage and light at Bear Valley, Burnside, Sterling, Henry Clay and Big Mountain collieries.

Electrical Correspondence

Commutator Slotting Device

SEVERAL DESCRIPTIONS of commutator slotting devices have appeared lately in the technical papers which prompts me to send you the enclosed sketch of a commutator slotting device that is easily made and used. It consists of a piece of machine steel ⅞ in. square by 5½ in. long, a hacksaw blade and a suitable handle made from a plane handle or grip or a shoe brush handle.



CONVENIENT FORM OF COMMUTATOR SLOTTER

The ⅞-in. steel is milled out and a hack saw blade is inserted in the slot provided and clamped tight by means of 3 fillister head 14-24 screws. This arrangement makes a neat and serviceable tool for anyone having considerable slotting to do. C. E. ANDERSON.

Electrical Problems

GIVE SOME reasons for not using 500 cycles instead of 60 cycles on power and lighting circuits feeding from long transmission lines.

2. A circuit has the following constants:
Voltage = 1000.
Noninductive resistances = 200 ohms.
Inductive reactance = 100 ohms.
Condensive reactance = 75 ohms.
Frequency = 25 cycles.
How would I find the following:
A. Current in circuit.
B. Inductance in henrys.
C. Capacity in farads.
D. Power factor of circuit.

3. The voltage across each phase of a 2-phase circuit is 440 volts. What is the voltage between the 2 phases?

4. A generator connected and having a voltage of 100 across each leg, connected to a bank of delta connected transformers, what is the voltage across each transformer?

5. A circuit contains an inductance coil having 5 henrys inductance and capacity of 50 microfarads. What is the critical frequency?

6. (a) What value of a direct-current wave is indicated by a direct current instrument of the ordinary magnetic type? (b) What is the value of an alternating wave that would be indicated on an alternating-current

instrument? (c) What name is given to the ratio between the effective and average values?

7. What is the amplitude of an alternating-current wave? V. K. S.

A. The reason for not using 500 cycles is, first, that you would have to have a machine running at a terrific speed in order to get this; second, that the iron losses in your generators, motors and transformers increase rapidly with increased frequency, and also there is a greatly increased inductance in the machinery and in the lines.

2. Performing the operations to get the required values:

A. The current in the circuit will equal the electromotive force divided by the impedance. This impedance will be the resultant of the resistance and the reactances. Inductive reactance is directly opposite to condensive reactance, so that the total reactance in the circuit will be the difference between these two, or in your case, 25 ohms. The impedance is then found by taking the square root of the sum of the squares of resistance and net reactance; 200 squared is 40,000; 25 squared is 625; the sum of these is 40,625, and the square root of that is 201.5. This is the impedance of the circuit. Dividing the electromotive force, 1000, by this, gives 4.96 amp.

B. The inductive reactance is equal to 6.2832 times the frequency times the inductance in henrys; or, turning this around, the inductance will be equal to the reactance divided by 6.2832 times the frequency, or in your case, $100 \div (6.2832 \times 25)$. The parenthesis is equal to 157; dividing 100 by this we get 0.637 henrys.

C. The condenser or capacity reactance is equal to 1 ÷ (6.2832 times the frequency times the capacity in farads), or, turning this around, the capacity equals 1 ÷ (6.2832 times the frequency times the reactance). In your case, this comes to $1 \div (6.2832 \times 25 \times 75)$. The parenthesis equals 11,750; dividing 1 by this we get 0.000,085 farads, or, as more commonly expressed, 85 microfarads.

D. The power factor of the circuit will be equal to the resistance divided by the impedance, or in your case, $200 \div 201.5 = 0.993$.

3. The voltage between the 2 outside lines of a 2-phase circuit is equal to the voltage of one phase multiplied by 1.41. In your case, $440 \times 1.41 = 622$ volts.

4. Transformers connected in delta across the lines fed from a Y connected generator, will have a voltage equal to the voltage of one leg of the generator times 1.73. As you have 100 volts on a leg, the voltage for transformer will be 173.

5. For a circuit containing both inductance and capacity, the critical frequency is found by dividing 1 by 6.2832 and the square root of (the inductance times the capacity). Your inductance is 5 henrys, and the capacity is 50 microfarads, or 0.000,05 farads. Carrying out the computation gives, as the critical frequency, 100.7 cycles per second.

6. In a direct-current circuit, the magnetic instrument indicates the average or arithmetical mean of the voltage in the circuit. In the alternating-current circuit, it indicates the effective value or the geometric mean, which is the square root of the mean squares. The ratio between the effective and the average value is the power factor.

7. The amplitude of an alternating-current wave is the distance from the positive maximum to the negative maximum, or, in other words, for a symmetric wave, the amplitude will be twice the maximum value in either direction. A. L. R.

Practical Arithmetic

SIGNIFICANT FIGURES IN MULITIPLICATION AND DIVISION. BY IRVING W. BOOTH

ARITHMETIC should be divided into 2 branches: First, exact or theoretical arithmetic. Second, practical arithmetic, as used in engineering and scientific work, where the data are physical measurements of known accuracy.

Theoretical arithmetic is taught in the schools. The problems deal with abstract numbers, or with imaginary data stated in integers or exact quantities. It is principally useful to bookkeepers, accountants, etc., to problems dealing with dollars and cents, this work being in integral amounts.

With the engineer or the scientist, the case is different. Here arithmetic is used as an aid to understanding the problems presented by actual physical facts. All our work is from measurements. We have no way of measuring any physical quantity exactly.

To save time, we should keep in mind the accuracy of the data and that of the result wanted, using no figures except those necessary to reach this accuracy. The mass of useless figures in multiplication can be avoided by working from the left instead of the old-fashioned style of working from the right. In division, there is no sense in annexing the useless ciphers to the dividend as required in the ordinary method; instead, one place is dropped from the divisor each time a figure is added to the quotient.

The first thing to determine, is the number of places of significant figures. Here is where many go astray. They believe accuracy is shown by the number of places off to the right of the decimal point. This is a common error. The decimal point and the ciphers adjacent to it, are located by the size of the unit as well as the accuracy. To illustrate, 185 millimeters is 18.5 centimeters, and 0.185 meters, or if you like, 0.000,185 kilometers. It is, therefore, an error to suppose that a number expressed 0.000,185 represents great accuracy, while 18.5 is a rather rough measurement. As a matter of fact, in the above example, the measurement is the same thing, only the unit is changed; that is, our data has 3 places of significant figures.

Again, suppose we measure a rod with a micrometer reading to 0.001 in., and we find it to be 0.256 in. The nozzle of a blower measured with a rule graduated to $\frac{1}{8}$ in. is $25\frac{5}{8}$ in. to the nearest $\frac{1}{8}$, and the length of a scaffold is 256 ft. to the nearest foot. Here are 3 measurements of equal accuracy; that is, to 3 places of significant figures.

For an example, let us take the above measurement of the blower nozzle. Suppose we wish to find the length of sheet from which to make the blast pipe; that is, the circumference. To do this, we multiply by 3.1416, and since $\frac{5}{8} = 0.625$, our multiplicand is 25.625. The work is shown in Fig. 1. The answer is $80\frac{1}{2}$ in.

Fortunately, the last 3 figures are ciphers, but the fact remains that we have a result to one ten-millionth of an inch. We work from data of 1/1000 in., obtained from a rule graduated to ⅛ in. and, having arrived at this wonderful result, we will add about 1½ in. to allow for lap of the seam. This is no joke; it is a fair sample of arithmetical calculations made every day. You can find them printed in engineering papers, too. We have used 36 figures and 26 of them signify nothing —except wasted time.

The sensible way to work an example of this kind, is to think just what you are going to do, before you do it. First, consider the data; 3 places of figures is all we can rely upon. Second, the result; the nearest ½ in. will do. For 25⅝, we will use 25.6 as near enough, and for the multiplier, 3.14 is far enough. Then, working from the right instead of the left, we will multiply as in Fig. 2, getting 80½ in., nearly.

Our work has now 7 figures to get a result of 3 figures, instead of 27 figures to get a result of 9 figures, only 3 of which are wanted.

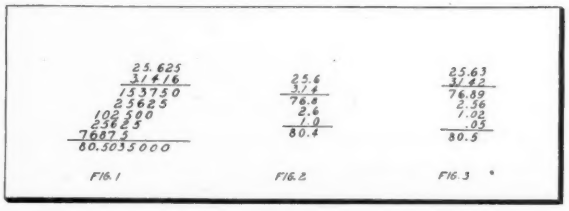


FIG. 1. COMMON METHOD OF FINDING CIRCUMFERENCE OF CIRCLE

FIG. 2. SHORT CUT METHOD OF CALCULATING CIRCUMFERENCE OF CIRCLE

FIG. 3. SHORT CUT MULTIPLICATION WHICH SECURES ACCURACY TO THE THIRD PLACE

It will be objected that our result is wrong in the third place, and that it should have been 0.5 instead of 0.4. But we started with the understanding that we wanted the nearest ½ in. Furthermore, our result is out only 0.1 in. in 80, or ⅛ of 1 per cent, while our data is to the nearest ⅛ in 25, so it may be out 1/16 in., or ¼ of 1 per cent, so the work is as accurate as the data and any increase in accuracy of work is wasted.

To illustrate, however, that this system will reach any desired accuracy, let us take the same example and suppose we wish it accurate to 3 places. To do this, we will carry the work through with 4 places, but use the same system.

The numbers in the fourth place are carried in the work; but after being added, the fourth place is not set down, being dropped, if less than 5, and carried into the third place as 1, if greater than 5. Thus, the fourth place column totals 22, the 20 carries 2 in the third place, the fourth place 2 is dropped. Had the fourth place column totaled 26, for instance, we would have carried 3 into the third place column.

We can show how the extra place is carried or dropped by considering the ratio of the circumference to the diameter commonly called pi.

For 3 places, pi = 3.14
For 4 places, pi = 3.142
For 5 places, pi = 3.1416
For 6 places, pi = 3.141,59
For 7 places, pi = 3.141,593
For 8 places, pi = 3.141,592,7
For 9 places, pi = 3.141,592,65
And so on.

Beyond the fourth place column, which is set down, the fifth-place figures—if any—are reckoned mentally and carried as one or dropped, according to the above principle. In scientific work, 2 places beyond the results wanted are carried and in some cases, 3 extra places; but the work is all from the right and all extra figures are discarded.

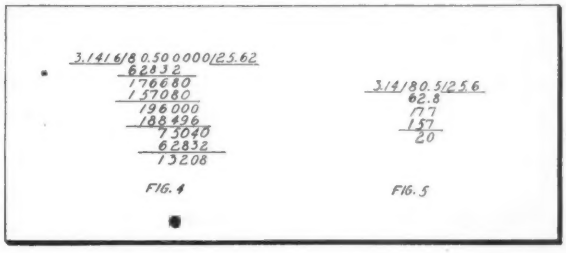


FIG. 4. COMMON METHOD OF DIVIDING

FIG. 5. SHORT CUT DIVISION

Division is the reverse of multiplication, and when carried out in the usual manner, is even more of a task. We will work the same example backwards; given the circumference, 80½ in., find the diameter. We call the ½, 0.5, add 5 ciphers and proceed to divide. (See almost any arithmetic.)

Almost anyone would know enough to stop after getting this far. The result is not exactly the same as the multiplication, because we assumed ciphers beyond the 0.5 place.

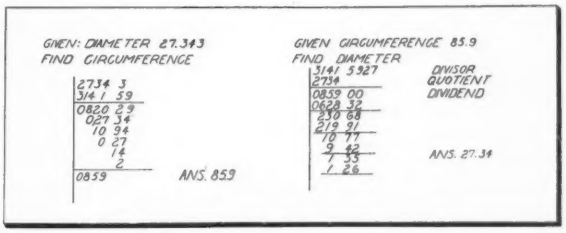


FIG. 6. LOCATING THE DECIMAL POINT

To shorten this work, we will use only 3 places in the dividend and divisor; and further, we will drop a place from divisor for each successive multiplication, getting 25⅝, nearly.

If the engineer will only keep his eyes open and think for himself while figuring, he will save many hours of work.

The first principle is to use no figures that denote an accuracy not warranted by the data. Next, shorten your work by omitting the useless figures that come from multiplying; in division, shorten in the same way.

Generally, 3 places are enough to carry unless the first figure is 1 or 2, in which case it may be well to carry 4; this is almost exactly the result that you get from the slide rule. With a little practice in the use of short cuts, a reasonably quick worker can make the man with the slide rule hustle in ordinary work.

In fact, in work that involves addition and subtraction as well as multiplication and division, the slide rule is nowhere; for, to add and subtract, the results of the rule must be set down. The pencil has the further advantage that the work can be checked through, step by step. The rule shows up strong in such work as continued proportions, squares, roots, areas, and in formulas especially arranged for logarithmic solutions.

Now comes the placing of the decimal point. As a matter of fact, it would be easy to evolve several rules; but, in general, it is easier to use a little common sense than to bother with a rule. If, for instance, we work out a case where so much water is pumped in so long, against so much pressure, and the result is, say, 15 hp. A mistake in the decimal would bring it either 1.5 or 150. It would be a poor dub who could not tell that either 1.5 or 150 was wrong and, consequently, 15 right.

However, in working from the left, the decimal is located with the first partial product. Thus, in the example given, 3 times 25 are 75, not 7½ nor 750, and we locate the decimal at once. In actual work, the point presents no difficulty whatever.

The object of this article will be accomplished if the engineer will only give up the usual view of arithmetic as an abstract science with a lot of set rules, and look on it as a help in making his estimates; a help to be used with common sense and discretion, not a burden, tying us up to a lot of antiquated rules, taught us in school, 10, 15 or 20 yr. ago. And stop setting down row on row of useless figures to arrive at a simple result, as though time were not the stuff that life is made of.

In a recent query, how to figure the horsepower of a vertical flue boiler, giving the dimensions, the figuring was as if calculating a logarithmic table. The fire box is 28 in. in diameter; this is multiplied by 3.1416 to get the circumference, giving a result to 0.001 in.

The fire box was probably measured with a wooden yard stick, having inches on one side and a hardware ad on the other, for that is accurate enough in this case, anyhow. The calculation gives 6 places from this kind of data; but, after getting 6 places in square inches, it divides by 144 and has only 3 places in square feet. Then it comes bravely back when it is horsepower, however, finding the boiler to be 7.89 hp.; that is, it gets right down to 0.01 hp.

That surely is great faith that 10 ft. of heating surface gives a horsepower. Seems as if 12 ft. were called a boiler horsepower once. And are not Heine boilers sometimes rated at 7½ sq. ft.? There must certainly be different kinds of horses in this world, and 0.01 of one of them a peculiar fellow to locate.

For the benefit of those who wish some high authority for anything new before accepting it, the latest article published along this line that could be readily found, was by William Fleetwood Sheppard, M. A., D. Sc., who, as early as 1884, was Senior Wrangler, and in mathematical work ever since. From his article published in 1911, these 2 examples, Fig. 6, are taken, one in multiplication, the other in division.

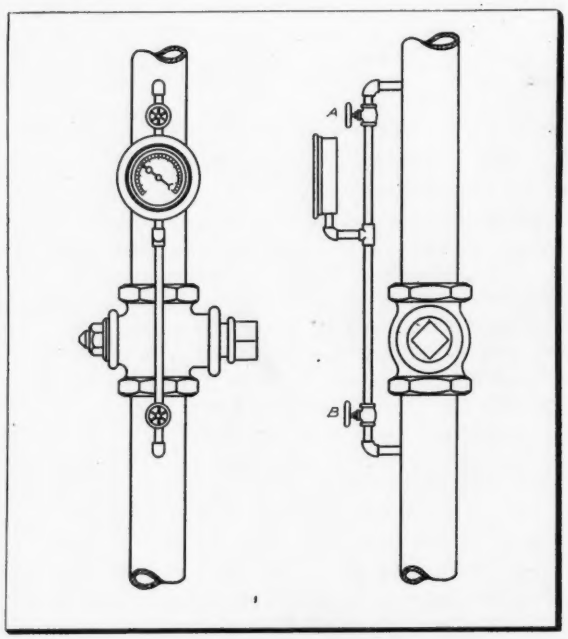
Notice how a space is left after the third place of figures. The other 2 places do not appear in result, but are carried to correct the third place. The cipher carried at the head in the multiplication example merely fixes the decimal point by accounting for enough places. Notice that the multiplication is from the left.

Notice the arrangement in division. The divisor is first written, a space left for the quotient, a line drawn and the dividend then written below. The divisor is multiplied through as far as necessary by each digit in the quotient as set down; the open space indicates the accuracy necessary. This arrangement is far superior, where any considerable number of places is used, to the conventional arrangement for division given above. Those who are free enough from tradition to receive new ideas are advised to practice it.

A Simple Means of Reducing Brine Pressures

By W. D. Spooner

In ice-making and refrigerating plants where centrifugal brine pumps are driven by constant-speed motors, it is sometimes found that the pressure is too high. In some plants, a much lower pressure is desired than that brought about by these conditions.



CONNECTION OF PRESSURE GAGE TO SHOW ORIGINAL AND REDUCED PRESSURE

In such cases, the pressure may be reduced by using an ordinary plug cock, preferably of brass, by placing it next to the pump if the pressure on the whole system is to be reduced, or in a branch line if the pressure on that part only is to be reduced.

When located next to the pump the pressure gage may be connected as shown in the cut; opening the valves A or B, the pressure on either side of the cock may be noted.

When the cock is located in a branch line, 2 pressure gages may have to be used. This, of course, will depend on the location and arrangement of piping.

By varying the opening through the cock, any reduced pressure within the range of pump can be had, and where a constant reduced pressure is to be maintained, the cock answers the purpose just as well as a more expensive automatic reducing valve.

What makes the arrangement so well adapted for use in connection with motor-driven brine pumps, is that under these conditions the speed is usually constant, and the arrangement may be used in connection with any type of pump whose speed is constant.

Where a steam-driven pump is equipped with the usual pressure regulator, it may be possible to produce a pressure that will answer the purpose; but where a much lower pressure is desired on a branch line, which might affect other parts of the system, the arrangement here shown can be used to good advantage.

Recently, trouble was had in a new ice cream factory on account of the cream congealing too quickly in the freezers. After an investigation it was decided that the flow of the brine was too rapid.

A cock, arranged as above, was placed in the branch line supplying the freezers, and after several trials, a pressure was obtained that gave the desired rate of freezing. No further trouble was experienced.

In the plant of which I have charge, 2 of these cocks were adjusted for pressure when the system was first started, and have never been moved since that time.

Measuring Air Flow With Pitot Tube*

ANALYSES OF PRESSURES; TESTS OF PITOT TUBES; FAN TESTS; DETERMINATION OF AIR FRICTION

AIR in motion in a conveying system is under the influence of 3 distinct pressures, namely, the velocity, static, and dynamic or total. It is necessary, therefore, that these pressures be clearly and definitely defined.

The velocity pressure is that pressure which is required to create the velocity of flow.

The static pressure, also termed the frictional or resistance pressure or maintained resistance, is that pressure required to overcome the resistance offered to the flow.

The total pressure, also termed the dynamic or impact pressure, is the sum of the pressures required to overcome the frictional resistance offered to the flow, and create the velocity of flow. In other words, the total pressure is the sum of the static and the velocity pressures.

For the many occasions where the measurement of volume, or of volume and pressure, is required, such as tests of fans and blowers for guaranteed performance, more accurate methods of measurement are often desired than have been commonly used, and the engineer needs something better than the ordinary anemometer to determine the velocity, or a rubber tube connected to a water gage to measure the pressure. Especially is this so in fan work—where the volume varies from nothing, with the outlet entirely closed, to a maximum, with an unobstructed discharge, and the measuring apparatus must be accurate through this wide range.

ADVANTAGES OF PITOT TUBE

THE PITOT TUBE used with suitable pressure measuring devices is particularly well adapted for measuring both the pressures and volume in fan testing. It has the advantage of being correct in principle, inexpensive, portable, and can be easily and conveniently arranged for testing purposes. It consists essentially of 2 parts: a tube pointing upstream against the flow of air or gas and which converts the sum of the static pressure and velocity pressure into a head which may be measured; and, as a second part, a means of determining the static pressure alone.

To overcome general distrust, due to the widely divergent results which are obtained by the use of different forms of tubes and to the lack of knowledge as to the correct methods of using the Pitot tube, there has long been a need for a careful, scientific study of it, and a fair comparison of the different forms in common use.

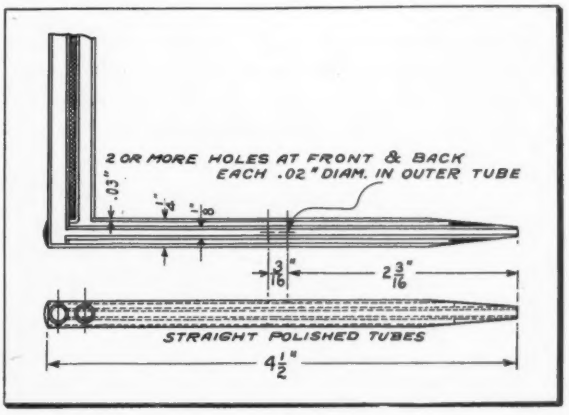


FIG. 1. FORM OF PITOT TUBE USED IN TESTS

The American Blower Co., as manufacturers of fans and blowers, early realized the necessity of being able to determine, accurately, the performance of such apparatus under various operating conditions. Before the necessary tests, upon which to base the performance of a fan, could be made, it was necessary to develop a Pitot tube which would give reliable and correct readings. To this end a series of experiments on various forms of tubes was conducted by the experimental engineering department and the form of tube as shown in Fig. 1,

*From a bulletin of the American Blower Co.

was adopted and has been in almost daily use for a number of years. This has been tested in many ways, as by measuring the same air through pipes of different diameters, by measuring the air in the same pipe with 2 or more instruments, and by measuring the air displaced by a gasometer.

It has been satisfactorily proven and accepted that the total or dynamic pressure tube gives correct results if the tube is parallel with the air current. The form of the tube may be changed from a straight open tube pointing into the current, to a small orifice, as in Fig. 1; or it may be flat at the tip with a small orifice in the center and still show practically no difference in the readings for the different shapes. Therefore, any ordinary change in the total pressure tube does not result in any inaccuracy. But it is a very difficult matter on account of secondary velocity effects, to obtain an orifice which will give correct readings of the static pressure. A study of the accuracy of the Pitot tube, therefore, resolves itself into a study of the correct method of obtaining the static pressure.

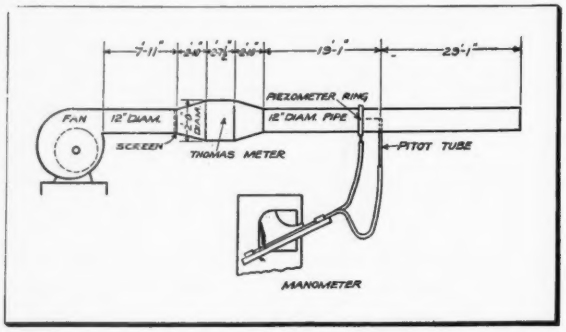


FIG. 2. ARRANGEMENT OF APPARATUS FOR CALIBRATING PITOT TUBE

The form of Pitot tube used by the American Blower Co. was adopted only after thorough and careful investigations and experiments which proved its accuracy and the reliability of the readings obtained by its use.

Comparison with Thomas Meter

It is obvious that the best means of determining what form of Pitot tube gives accurate readings is to compare the results obtained with the results obtained by the use of an instrument concerning whose accuracy there can be no question. For the measurement of the volume of air or gas flowing in a pipe the Thomas electric meter is known to be an instrument which gives correct readings and the accuracy of which nobody doubts.

This meter is based on known physical laws of gases, and its principle has been used and accepted as standard in a great number of tests for the determination of physical constants.

Gas is passed through an insulated pipe in which there are 2 electric resistance thermometers, and between these an electric heater whose energy is carefully measured. Knowing the specific heat of the gas, the rise in temperature, and the energy used in heating, it is a simple matter to compute the pounds of gas flowing per minute, and as all measurements are electrical, they can be made with extreme accuracy.

The rule is: $3.412 \times$ energy in watts $\div$ ($60 \times$ temperature rise $\times$ specific heat of gas) = pounds of gas per minute. The Thomas meter is made by the Cutler-Hammer Mfg. Co., and has frequently been used in scientific tests requiring the greatest accuracy.

Method of Making Tests

The fan was direct connected to a direct-current motor whose speed could be varied as desired by means of controlling rheostats. The speed of the fan was indicated by a dial tachometer. With no current passing through the heater of the Thomas meter the 2 thermometers were checked for their zero reading. The heat was then applied to the Thomas meter until the thermometers indicated that the temperature of the air had been raised through a known range. As soon as these conditions were constant, readings were taken on the Pitot tube. In order to determine the actual condition of the air at the point where the Pitot tube was inserted, its temperature and humidity were determined by wet and dry bulb thermometers and the barometer and room temperatures were read at the same time. Both the static pressure and velocity pressure as indicated by the Pitot tube were read on accurate manometers filled with gasoline, and in addition the static pressure was also determined by means of a Piezometer ring.

Readings were taken on the Pitot tube across the section of the pipe both vertically and horizontally, 10 readings in each plane, the average velocity head for the whole section being found from the 20 readings. From the temperatures of the wet and dry bulb thermometer, inserted in the pipe just behind the Pitot tube, the relative humidity was determined from the humidity chart used by the Department of Forestry of the United States, and the actual vapor pressure of the air at the Pitot tube was determined from the relative humidity. The barometric pressure added to the static pressure gave the total pressure of the air at the Pitot tube and, deducting from this pressure the actual vapor pressure, the pressure of the dry air alone in the mixture was determined. The weight of one cubic foot of dry air was determined from the formula $P V = R T$, where P is the absolute pressure in pounds per square foot of the dry air alone, V the volume in cubic feet, R a constant equal to 53.35, and T the absolute temperature equal to 460.7 plus the observed degrees Fahrenheit. The actual weight of the vapor was determined by Marks and Davis' steam tables and the known relative humidity. The sum of the weight of the dry air and the actual weight of the vapor per cubic foot, gave the weight of one cubic foot of the mixture passing the Pitot tube. The specific heat of the dry air and the specific heat of the vapor being known, the mean specific heat of one pound of the air mixture could be calculated. From the average velocity head measured in inches of gasoline, and from the known weight of 1 cu. ft. of the air mixture, the volume in cubic feet per minute as indicated by the Pitot tube was calculated.

On the Thomas meter the proper corrections were applied to the readings of amperes and volts and the watts input was determined. The number of pounds of air per minute was then calculated from the formula.

It should be noted that the result given by the Thomas meter is a measurement of mass, and has no relation, nor is it dependent on the temperature or pressure of the air as it passes through the meter. Hence, since the weight of one cubic foot of air passing the Pitot tubes has already been determined, the volume measured by the Thomas meter can be determined by dividing the weight indicated by the Thomas meter by the weight of a cubic foot of air.

Results of Tests

A series of tests was run by varying the speed of the motor. The results of these tests are shown by Fig. 3.

By averaging the observed discharge for all tests in each series as measured by both the Thomas meter and the Pitot tube, the ABC tube averages 1.62 per cent below the Thomas meter.

During the tests, as already stated, readings were made of the static pressures as given by the Pitot tubes, and also by a Piezometer ring, which consisted of a galvanized iron channel bent to the circular form of the pipe and soldered firmly to it so as to form an absolutely air tight annular space about the pipe. A nipple was connected on the outer edge of this ring and a rubber tube led to a manometer, M, where the static pressure was read in inches of gasoline. The annular ring around the pipe formed by the Piezometer ring was connected to the inside of the pipe by 6 holes spaced equally around the circumference and about 3/16 in. in diameter. This Piezometer ring measured the static pressure at the point where the Pitot tube was inserted in the pipe.

The averages of the static pressures for the tests covered by Fig. 3, and at the same speeds that the points on these diagrams were plotted to, are shown in the following table:

Static Readings

Fan Speed R. P. M.	Piezometer	"ABC" Pitot Tube
825	0.32	0.34
975	0.43	0.44
1125	0.60	0.64
1275	0.79	0.79
1425	0.98	1.02
Average	0.624	0.646

The average static pressure as read by another form of Pitot tube was 53.7 per cent higher than by the Piezometer ring. The average static pressure by the ABC Pitot tube was 3.5 per cent higher than by the Piezometer ring.

The Pitot tube, as already stated, consists essentially of 2 parts, one of which determines the total pressure and the other the static pressure. The difference between the total pressure and the static pressure is the velocity pressure, which determines the head in the formula for calculating the velocity, which equals the square root of 64.3 $\times$ head.

It has been shown that the total pressures as given by the ABC and other tubes are the same, and also that the static pressure read varies considerably with the form of tube.

It is readily apparent why the static readings are erroneous where the static orifices are long slots and relatively large as compared with the small static orifices of the ABC tube. Large orifices are admittedly more liable to be influenced by the flow and motion of the air than small orifices. It has been proven that the long slots receive, in addition to the actual static pressure, a part of the velocity pressure, thereby recording a higher but false static pressure. The false static pressure subtracted from the total pressure, which is correctly recorded, gives a velocity pressure which is considerably lower than the actual velocity pressure.

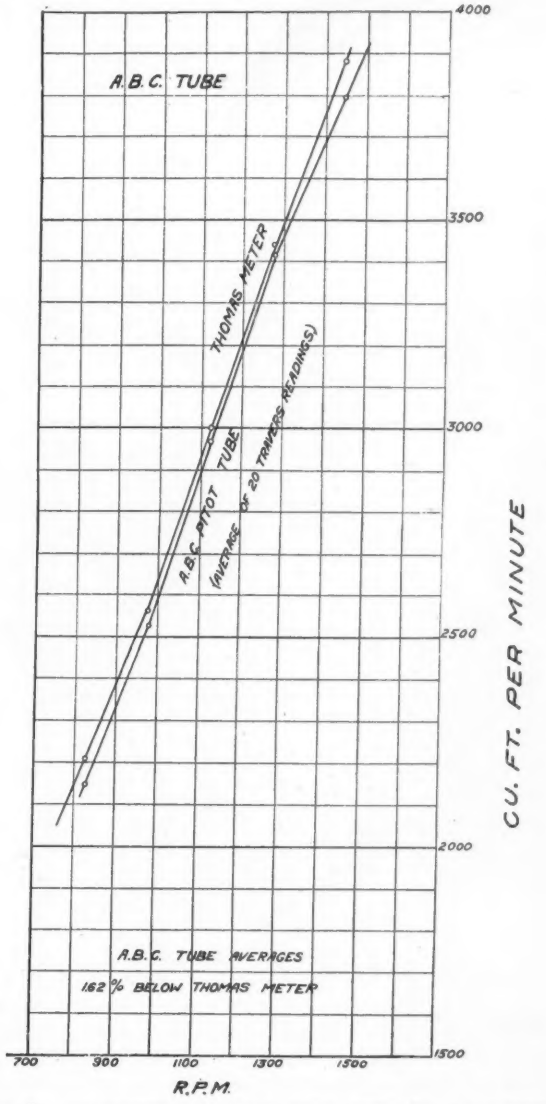


FIG. 3. VOLUMETRIC RESULTS FROM TESTS OF A B C PITOT TUBES AGAINST THOMAS METER

Conclusions Based on Recent Tests

Comparison of the results obtained in some recent tests conducted at the University of Wisconsin from 13 forms of Pitot tubes with the results given by the Thomas electric meter and the Piezometer ring lead to the following conclusions:

1. The Pitot tube as a means of measuring air or gases is reliable within approximately one per cent when the static pressure is correctly obtained.

2. All the various forms of Pitot tubes used gave accurate readings of the total or dynamic pressure.

3. The ABC form of Pitot tube gives the most accurate and reliable readings of the static pressure of any form of Pitot tube.

4. Long slots for obtaining the static pressure are not reliable, and give results which are in error.

5. The results obtained by use of the ABC Pitot tube check those given by the Thomas meter within approximately one per cent under all conditions.

Method of Conducting Fan Tests

The customary arrangement of the testing apparatus for a test on the discharge side of the fan, that is for blowing, is shown by Fig. 4. When air is discharged into a pipe by a fan, both static and velocity pressures, measured from atmospheric pressure, are positive. When air is drawn from a pipe by a fan the static pressure in the pipe is always less than atmospheric, that is, it is negative. The reading given by the

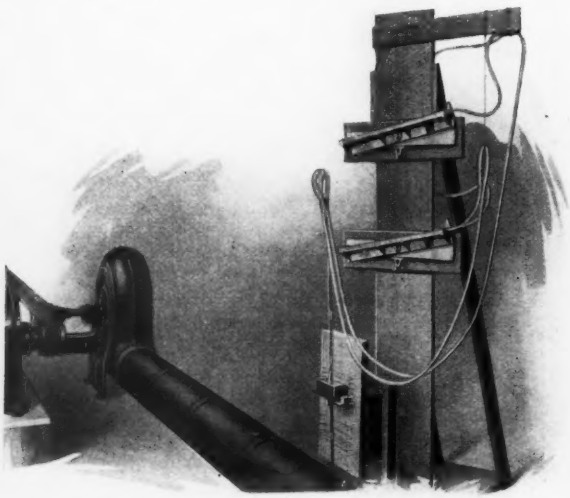


FIG. 4. ARRANGEMENT OF APPARATUS FOR BLOWING TESTS

impact or total pressure tube will also be negative, but less than static. The static pressure subtracted from the total pressure gives a positive reading, as it should, for the velocity pressure.

The arrangement of the connections from the Pitot tube to the manometers for a test on the discharge side of a fan, or for blowing, is shown by Fig. 5a, and for a test on the inlet, or for exhausting, by Fig. 5b. Due to the irregularities of the flow of air the Pitot tube should be located at least 20 diameters of the test pipe from the fan, so that the flow will be as nearly uniform across the section of the pipe as possible.

For the measurement of pressures from 1 in. to 3 ft. of water, ordinary manometers are accurate. For pressures of 1 in. or less, the inclined manometer, Fig. 4, containing gasoline instead of water, affords a simple and reliable means of measurement. The inclined manometer can be made so that it will give very accurate results when inclined as much as 40-in. slant for 1 in. vertical reading. Water is not a satisfactory fluid in a manometer inclined more than 3 to 1 and gasoline should be used, as it automatically keeps the inside of the glass tubes clean, has a very definite meniscus, and almost no capillary attraction for the glass. With the inclined manometer, velocities as low as 400 ft. a minute may be satisfactorily measured.

In fan testing, readings at different restrictions of the area of the test pipe are required and it is convenient to measure the wide range of pressures with one manometer by simply changing the angle of inclination. Both the Pitot tube and the rubber tubing connecting the manometers and the Pitot tube should be tested for air leaks before the tests are started.

The velocity of air flowing through a pipe is greater at the center than near the walls of the pipe. Therefore, to obtain an average of the velocity of the air it is necessary to take a large number of readings across 2 diameters of the pipe. The total area of the pipe is divided into 5 or more zones of equal concentric areas and 2 readings taken in the middle of each zone, both across the pipe horizontally and vertically. Dividing the pipe into zones of equal area makes it possible to average the pressures to get the average velocity, without any appreciable error and, with considerable saving of time, otherwise it will be necessary to extract the square root of each pressure reading, and determine the velocity from an average of these.

For adjusting the Pitot tube within the pipe, 2 flat boards are provided, one placed horizontally and the other vertically, Fig. 5. The Pitot tube is fitted to a suitable holder and provision made on the guide boards for adjusting the holder so that the positions of the Pitot tube in the pipe will be known. The boards are so arranged that the Pitot tube in any position on the provided stops will have its axis parallel to the axis of the pipe. Provision should be made for keeping the pipe absolutely circular at the point where the Pitot tube is inserted.

Tests are made in both the vertical and the horizontal positions and readings taken at points as already stated, 20 readings in all on each test if 5 zones are used. It is essential to determine the relation of the volume of air discharged, the pressures and the power required as the resistance against which the fan is operating changes. To provide this changing resistance the area of the test pipe is restricted to different amounts.

With the full area of the test pipe, the condition of high air velocity and low static pressure is provided and with the area restricted, the condition of low velocity and high static pressure results. If the end of the test pipe is partially closed, the effect, as regards the resistance against which the fan must operate, is the same as attaching the fan to a system of ducts. In blowing tests the outlet of the test pipe is restricted and for exhausting tests the inlet is restricted.

Thin, flat plates with round orifices are used for restricting the area of the test pipes and it is usually ample to test a fan with the pipe full, ¾, ⅝, ½, ⅜, and ¼ open and entirely closed off. The area of the opening divided by the area of the test pipe is the ratio of opening or equivalent orifice. The power re-

quired for driving a fan is determined by means of one of the usual forms of dynamometers or by the power input of an electric motor which drives the fan.

Calculations

The relations between fan speed, pressures, volume delivered and power required have been fully verified by tests and under the same conditions of air density and with the same fan are as follows: a. The volume of air discharged by a fan varies directly as the number of revolutions; b. The pressures produced vary as the square of revolutions; c. The power required to drive the fan varies as the cube of the revolutions.

In making fan tests the speed may not be constant at all times for a particular test and the above relations are used for making corrections for a common speed.

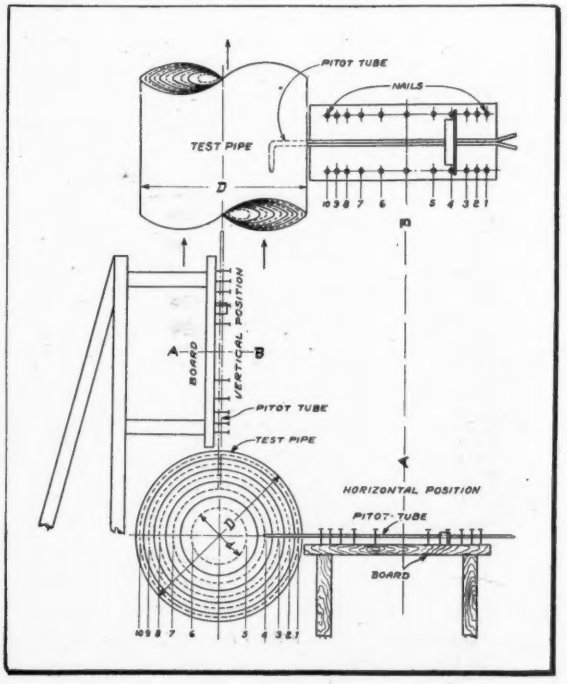


FIG. 5. METHOD OF ADJUSTING PITOT TUBE

It is important to have a standard weight of air at which fan performances may be compared. The density, while ordinarily a small factor, affects the results considerably if extremes are great, as with heated or cold air and air at high altitudes.

The basis for calculating the velocity at which air is flowing in a pipe is found in the law of falling bodies, expressed by the formula:

$$v = \sqrt{2gh};$$

where v equals the velocity in feet per second, g equals the acceleration due to gravity, or 32.16 ft. per sec., and h the mean velocity head of the air flowing. If a given pressure is maintained at the outlet of a fan, the velocity of discharge will be the same as for a column of air of a height which would exert a pressure at its base equal to the pressure being maintained by the fan. In fan testing, the head corresponding to any given velocity is usually expressed in inches of water. It is, therefore, convenient to change the fundamental formula so as to express the pressure in inches of water instead of a column of air of a given height. Converting h so as to use the pressure in inches of water, we have:

$$h = \frac{62.3\,p}{12\,w}$$

where 62.3 equals the weight of 1 cu. ft. of water. Substituting in above formula, the velocity in feet per second can be determined as follows:

$$v = \sqrt{\frac{64.32 \times 62.3\,p}{12\,w}}$$

$$\text{or } v = 18.27\sqrt{\frac{p}{w}}$$

Expressing the velocity in feet per minute, the formula becomes:

$$V = 1096.2\sqrt{\frac{p}{w}}$$

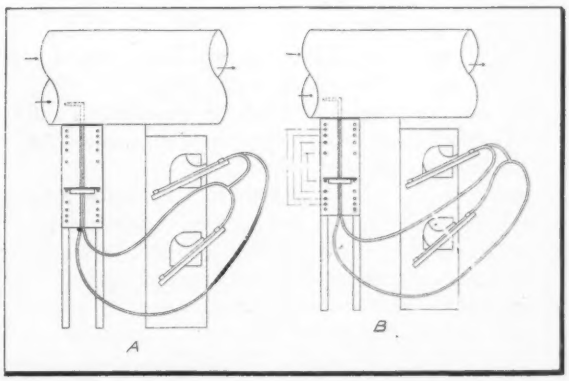


FIG. 5A AND B. ARRANGEMENT OF CONNECTIONS FROM PITOT TUBE TO MANOMETERS FOR BLOWING AND EXHAUSTING TESTS

The average weight of 1 cu. ft. of air from a large number of tests extending over a number of years, was 0.0715 lb. per cu. ft., and substituting this value in the formula, we have:

$$v = 4101\sqrt{p}$$

p = Velocity pressure in inches water gage.

v = Velocity of air in feet per second.

w = Weight of 1 cu. ft. of air, under existing conditions.

For the same pressure the velocity will vary inversely as the square root of the density of the air and for the same velocity the pressure will vary directly as the density.

The velocity of flow of air at a given density, which will be produced by a pressure of 1 in. of water, is known as the "velocity constant" of air at that density. A table of velocity constants for air at different temperatures, and, therefore, at different densities, is given in the Practical Reference Tables.

The effect of moisture in the air may usually be neglected, as the difference in the density due to this cause occurs in the fourth decimal place, even with a relatively high percentage of humidity.

The horsepower developed by the delivery of air against a certain pressure is expressed by the formula:

$$A = \frac{C \times W \times H}{33{,}000}$$

The head in feet of an air column equal to total pressure may be expressed in inches of water as follows:

$$H = \frac{5.2 \times D}{W}$$

Substituting this in the air horsepower formula for H, we have:

$$A = \frac{C \times D}{6356}$$

A = Air horsepower.

H = Head in feet of air column.

W = Weight of a cubic foot of air under existing conditions.

C = Cubic feet of air per minute.

D = Dynamic or total pressure in inches water gage. 5.2 lb. per sq. ft. equals 1-in. water gage.

The air horsepower divided by the power required to drive the fan, as measured by the dynamometer, gives the mechanical efficiency of the fan.

The pressure rating of fans is made on a basis of either the total pressure or the static pressure at the fan outlet, some manufacturers using total pressure and others static in making up fan capacity tables. This fact should be borne in mind when making comparisons of fans manufactured by different companies. It is evident that if a fan is to perform the tabulated duty, the conditions as to pressures and volumes under which the fan is rated, must be reproduced in practice. Unless this is fully realized, disappointing results are likely to occur.

Two charts in the Practical Reference Tables show the frictional resistance in inches water gage due to the flow of air in 100 ft. of straight galvanized iron pipe, of average circular formation, for all diameters from 4 to 140 in., and for velocities ranging from 400 to 10,000 ft. per min.

Another table shows the frictional resistance of elbows of various radii in the throat of the elbow expressed in diameters of the pipe or elbow, the result being expressed in the number of diameters of straight pipe offering an equivalent resistance.

An example will clearly illustrate the facility with which the friction can be determined, thus: Assume it is desired to discharge 40,000 cu. ft. of air per minute through a duct 50 in. in diameter and 75 ft. long. Find 40,000 cu. ft. on right-hand margin of the chart; follow horizontal line across to the left until it intersects with diagonal line marked 50 in.; now follow down perpendicular line marked to bottom or top of chart, where will be found the friction in inches of water, which, in this case, amounts to 0.31 in. per 100 ft. of pipe. As the friction is in direct proportion to the length, then for 75 ft. the friction will be: $\frac{0.31 \times 75}{100} = 0.2325$ in.

Assuming again that there are 2 elbows in the above 50-in. pipe, one having a radius in the throat of the elbow equal to the diameter of the pipe, or 50-in. radius, while the other has a radius equal to 2 diameters, or 100 in.

From the table find below radius of one diameter, 10 diameters for length of equivalent straight pipe, and opposite radius of 2 diameters, 4.3 diameters. Hence: $\frac{50 \times 10}{12} = 41.66$ ft., and $\frac{50 \times 4.3}{12} = 17.91$ ft. The sum of these amounts to 59.57 ft., or, say, 60 ft. of 50-in. pipe. Therefore, $\frac{0.31 \times 60}{100} = 0.186$ in. friction. Adding this to friction of straight pipe, as already determined, makes the total friction amount to 0.4185 in.

The chart can also be used for rectangular ducts by reducing the latter to round ducts having the same frictional surface in the walls of the pipe, thus:

$$d = \frac{4\,a\,b}{2\,(a+b)}$$

a = width of a rectangular pipe in inches.

b = depth of rectangular pipe in inches.

d = diameter of round pipe in inches, in which the air is flowing at the same velocity that will set up the same frictional resistance as the rectangular pipe.

The shape of a rectangular pipe has a decided effect on the friction; for example: a 12 by 12-in. pipe offers the same friction as a 12-in. round pipe, whereas a 24 by 6-in. pipe, though having the same area as the 12 by 12-in. pipe, presents as much friction as a round pipe only 9.2 in. diameter. In other words, while the carrying capacity of the 24 by 6-in. pipe, as compared with a 9.2-in. round pipe, is more than double at a given velocity—yet the frictional resistance to the flow of air is the same in either case.

Following are a few conventional rules which are often of value:

Inches water gage may be converted into ounces per square inch by multiplying by 0.58 or by dividing by 1.728.

Friction for varying diameters of round pipes is inversely proportional to the diameter at a given velocity.

For rectangular pipes, the friction varies inversely as the square root of the area.

Friction varies directly as the square of the volume at a constant temperature.

Friction varies directly as the density of the air.

The density of air decreases inversely as the increase of the absolute temperature.

Absolute zero is assumed to be—459.2 deg. F.

The charts show the friction considerably higher than it actually amounts to in a perfectly smooth, round sheet iron pipe, to make allowances for dents, rivets and occasional roughness of surface.

LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

Home-Made Planimeter

I ONCE made a planimeter out of sheet brass, that was so exceedingly simple and gave such surprisingly accurate results that I believe a description would not be out of order. I checked up the areas of indicator diagrams about as shown in Fig. 1, which had previously been measured with a regular, more expensive, integrating planimeter, and was pretty well satisfied with results.

The planimeter is a piece of flat brass, bent into the form shown, pointed at one end (the left end on the drawing) and drawn to a sharp point at the other end to trace out the area to be measured. This point must not come in contact with the paper. The piece is bent into the form shown, in order that there will be 2 flat, smooth bearing surfaces at each end, and the measuring should be performed on smooth paper lying on a perfectly horizontal table. The tracing point is pulled or pushed around, as the case may be, by means of an eye hook, as pictured, thus reducing the friction between the 2 pieces of metal as much as possible. If the hand were used directly in tracing out the curve, friction between the fingers and planimeter might be great enough to affect the accuracy of results.

Lay out the diagram to be measured, about as shown, and place the tracing point over any convenient starting point on the diagram. Then mark the position of the blunter end, as at A. Trace the diagram "clockwise" by means of the eye hook, and the blunt end will be observed to swing toward the right after a complete circuit of the card has been made. Make another circuit and distance BC will have been passed exactly equal in length to AB. Two more circuits will bring the blunt end to point E, and it will be found that the distance AE is exactly 4 times the distance AB. The stopping point in each circuit, of course, must be identical with the starting point.

Now, before you can calculate the exact area, you must first calibrate the instrument in a manner similar to that suggested in Fig. 2, where I have laid off an area 1 in. square. After making one complete circuit, as already explained, the distance FG passed through by the blunt point will represent 1 sq. in. After 4 circuits, the blunt point will lie at J, as indicated by dotted lines. These distances can then be divided into tenths, and you are ready to attack your problem. If FG, for example, should happen to be $\frac{7}{8}$ in., and if AB should happen to be $\frac{1}{2}$ in., the area of the indicator diagram would be $\frac{1}{2} \div \frac{7}{8} = 4/7$ sq. in. It makes no difference what your scale is—eighths, sixteenths, tenths or hundredths—only you must use the same scale in both cases.

It is not my intention to recommend this as an instrument better than the regular type of planimeter; I merely give it as a practical device for use in emergencies, and know it to give more accurate results than many of the more cumbersome "approximate" methods about which we often read.

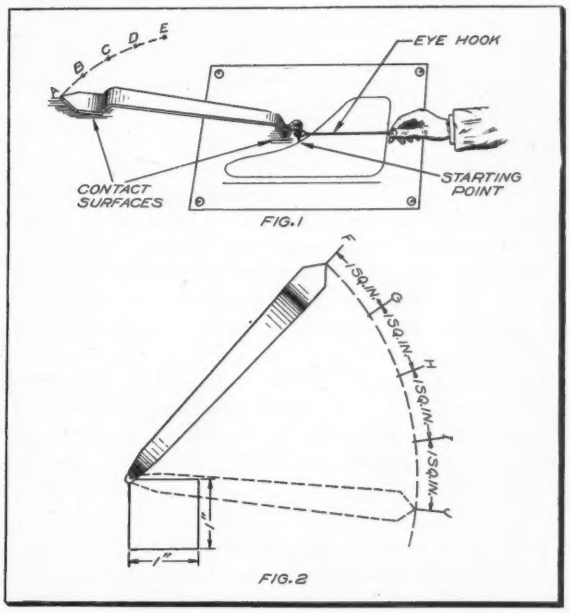


FIG. 1. MEASURING AREA OF INDICATOR DIAGRAM
FIG. 2. METHOD OF CALIBRATING THE PLANIMETER

Where the area to be measured is large, make the planimeter long enough so that it will act in the manner shown here. The instrument is so easily made that it requires only a few minutes to chip and file out several of them of various lengths. N. G. NEAR.

Central Station Rates

IN THE issue of April 15, A. S. asks me whether a public service commission which sells electric current (at a loss) at 15 cents per kw.-hr. should be denied the right of adding a load for which it may receive 2.3 cents per kw.-hr., in order to make the station operation profitable.

Analyses of costs of operation made by public service commissions proves, with certainty, that the expenditure for fuel and engine room supplies constitutes not less than 15 per cent of the total cost of current sold by central stations. If, then, the total cost of energy delivered

by the station to which A. S. refers, exceeded 15 cents per kw.-hr., the expense of the fuel and supplies consumed in its production was 2.25 cents or more per kw.-hr. sold. At 2.3 cents current would, therefore, be sold to the manufacturer for the cost of the power house supplies necessary to produce it.

Assuming that peak loads were coincident, the customers of this station who paid 15 cents a kw.-hr. would contribute the cost of depreciation, repairs, management, taxes and distribution, or about 13.75 cents per kw.-hr. to the manufacturer who paid only 2.3 cents.

"Discrimination is the arbitrary imposition (by a public service commission) of unequal tariffs for substantially the same service."

The 2.3-cent rate is then rank discrimination, the same in character but more flagrant in degree than the railroads at one time afforded the oil and meat-packing companies. The theory was the same as that which A. S. now champions: The railroads had the tracks, cars, engines and employes. They reasoned that any rate which returned more than the cost of fuel and supplies necessary to transport these products was "velvet."

Discrimination is illegal, because it wrongfully sequesters the property of one person for the benefit of another. In a well-balanced, modern public service electric station, every profitable kw.-hr. pays some proportion of the cost of management, taxes, depreciation, transmission and its full prorata proportion of the production expense. Accounting which transfers these charges from one customer to another is juggling.

If A. S. cares to send me a complete and accurate analysis of the operation to which he refers,—number of kw.-hr. sold, cost of management, taxes, depreciation, repairs and expenses incident to production,—I will endeavor to apply these principles to that particular plant and operation. H. W. ASHLEY.

Do Not Blow Down Boilers

THAT THE old method of blowing down boilers is wrong, I can prove to any reader of this publication. I have in my charge 5 boilers—2 100 hp. each and 3 B. & W. boilers, 2 at 125 hp. each and 1 at 150 hp.

Our water at the last qualitative analysis was as follows:

1. Lime—Present, not in excess.
2. Magnesium—Present, in excess.
3. Silica—Present, not in excess.
4. Ammonia—Present, in excess.
5. Chlorides—Present, in excess.
6. Iron—Present, not in excess.
7. Alumina (clay)—Trace only.
8. Sulphates—Present, in excess.
9. Nitrates—Present.
10. Bicarbonates and free carbonic acid—Present, not in excess.
11. Alkaline Carbonates—Present.
12. Acidity—Very strong acid reactions.
13. Organic Matter—Trace.
14. Hardness—Moderately hard.
15. Per cent of solids—4.65 oz. per ton.

The superintendent changed the compound a number of times, but did not better conditions.

We were compelled to get the scale out of the boilers by the sweat of our brows, still increasing the quantity of compound used every day.

We blew the boilers down once every day, then we blew every other day. The firemen blew for compound, I blew the company's money, the engineer, the fireman, and I would be blowing yet if I had not thought that some of us would probably get our heads blown off if we did not stop that.

I thought of a new plan. We decided to change the compound to one that we used about 8 yr. ago and that gave us good results, but did not use it in the same way in which I am using it now.

The compound is made by James E. Dale Co., Rahway, N. J. I can recommend it to any one who may read this. The following is the way I treat my boilers now: I have to use the turbine only once a year; before, I used it every time I took a boiler off and worked hard at it. Now we do not work hard and we also save time, save money for the company, save steam and coal, and the boilers are just as clean as the day they were put in.

First. I exercise care in putting the compound in the boilers. I fixed a barrel alongside of the feed pumps, and connected it with steam, so I could keep a little steam on the barrel all the time.

Second. I connected the barrel to the city water, so I could fill the barrel without using a pail.

Third. I drilled a ½-in. orifice in the bottom of the barrel, and connected it with the suction pipe of the feed pump; then I mixed 4 lb. of compound in a little warm water, put the mixture in the barrel full of warm water and on the ½-in. pipe between the suction and the compound barrel I have a ½-in. plug valve, which I set to run the entire time the boilers are in service.

I do not allow any of my men to touch the blowoff until the boiler is taken off.

All that it necessary when taking boilers off is to wash them and put them back again.

In January, 1914, the boilers were inspected and the inspector said they were in the best condition he ever saw them. The plant was completed in 1902—12 yr. ago.

Fourth. I keep a book with the record of each boiler, when taken off and when put on. This is necessary if you try my plan.

Each boiler must be taken off once a month, oftener if possible.

If you blow off every day, you will blow off your compound as well as the mud. If you try my plan, you get full use of your compound, and it will have the right chemical action—it will keep the mud soft.

If you let your boilers run overloaded longer than one month, this plan will not stand good.

Especially B. & W. Boilers or any water-tube boilers you had better blow off every day about 6 sec., just enough to remove the mud from the mud drum, otherwise it is liable to bake on the 2 bottom rows of tubes of the boiler and cause the tubes to bulge or blister near the bridge wall in the fire box. The reason for

this is that when a boiler of this kind is overworked, the circulation in the boiler is so rapid that not sufficient water reaches the 2 bottom rows of tubes to keep the mud from caking on them.

If you are overworking any boiler, take my advice and stop it, or some day when you little expect it your boiler will stop you. In return-tubular boilers, you must be more careful; I would advise the same treatment. On this boiler, the mud will bake on the crown sheet instead of the tubes, but the same action takes place.

FRANK BOHE.

Steam Pump Repair

WHEN reading his letter in the April 1 issue, Mr. Bliven discovered he had omitted one step and has the following to say:

As the article in April 1 issue, under the head of "Repairing a Steam Pump," is misleading, I will correct it.

I stated that, after removing the cylinder head and tightening the piston nut, the pump ran fine. This was not the case, for the machine worked no better.

I then decided that the steam was leaking by one end of the chest plunger; in fact, leaking more steam than could escape through the reversing valve port, the result being that the plunger would not slide over to the opposite side of the chest and thus left the steam port open to the outer end of the cylinder.

To remedy this, I removed the steam chest cap, tapped a hole in it and inserted a ¼-in. pet cock. My reasons for this were, to let out the steam which was leaking by the plunger; then, when the reversing valve was pushed open, the pressure would drop lower than that at the other end, and thereby allow the plunger to move over, carrying the D slide valve with it and, of course, this would reverse the action of the pump.

F. H. BLIVEN.

Air Compressor Troubles

ACCOMPANYING IS a sketch of a steam packing ring we made for an 18 by 24-in. tandem air compressor. The piston was fitted with sectional packing of the Babbitt and Harris type, but the sections seemed to have slipped out of their proper positions on the tee heads and on opening the cylinder, we found the rings, springs, and tee heads that transmit the pressure of the spring to the ring in fragments and the spring sockets in the piston so badly worn we were under the necessity of putting in another style of packing; this we did and after a year's use it seems to be all right.

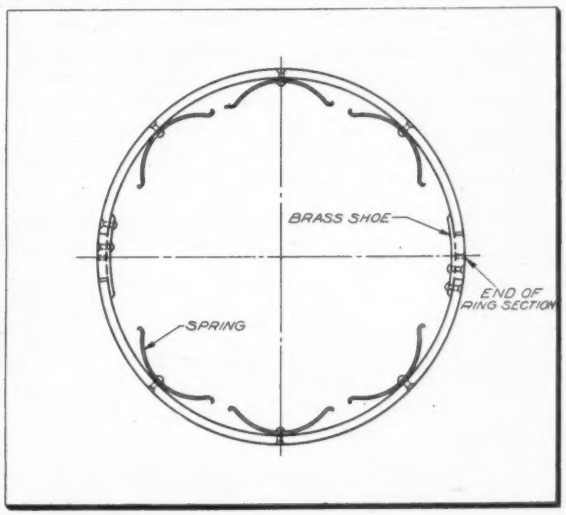
The leaf springs shown were made of spring steel bent up cold and left with the same temper as the original bar. In bending them cold they should be given more bend than if made hot, as they will give back a little before they will take their tension and hold it.

In making them hot I usually temper them by heating them and cooling in cylinder oil, then holding them over the forge fire until the oil burns; if the temper seems too high I dip them in oil and burn them off again.

But in this piston, and for the crab claw springs of the valve gear on this machine, of which we broke a number and for which paid the builder $2.50 apiece, we found the springs formed cold from the bar satisfactory, with no loss from breakage and a cost of 15c. as against $2.50 paid the engine builder.

In installing this air compressor, we failed to get a good job in grouting it in; as a consequence, in the course of 3 yr. the crank end got low, the grouting getting oil soaked and crumbling. I think the mixture must have been too lean. As a remedy, we raised that end of the frame to about its proper level, cleaned out the old grouting, took muriatic acid and cleaned the top of the foundation off, built a crib around it an inch higher than the bottom of the frame, mixed up a batch of half sand and half cement as thin as necessary to run freely, and poured it under the engine frame, working it back under, thoroughly, with bent pieces of strap iron.

Soapy water is sometimes recommended as a lubricant for air cylinders, but I see no value in injecting water into air of a temperature 400 deg. or more with a view to lubricating the moving parts; the evaporation



TWO-PART STEAM PACKING RING

of the water might reduce the temperature somewhat if supplied in proper quantities; anyhow, I don't believe the people who drink some of the water raised by this compressor would like soapsuds. A straight mineral oil does not emulsify and will separate from the water if given a chance.

There should be a good safety valve on the air receiver; we have had a couple of explosions due to the oil in the pipes and receiver gasifying, with no damage except ruining the spring in the pop valve.

In both cases, we had to shut the compressor down and turn a stream of water into the receiver to extinguish the burning deposits. We aim to keep the receiver reasonably free from oil and dirt.

J. O. BENEFIEL.

THE ANNEX to the Becker Brewing Co.'s artificial ice plant at Ogden, Utah, has been completed and the machinery is ready for installation. The building and machinery of the annex have cost the company in the neighborhood of $25,000 and the capacity of the plant has been increased about 50 per cent.

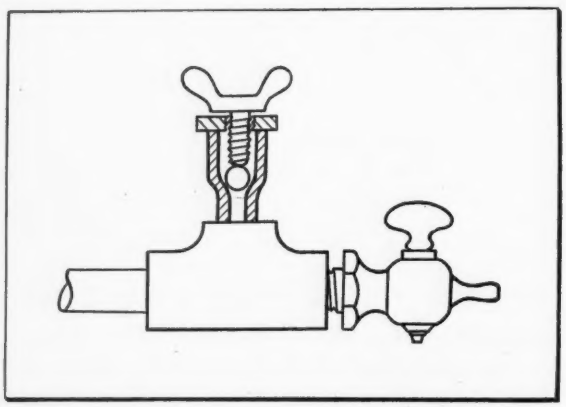
Successful Kinks From The Plant

For Saving Time, Work and Trouble

Dashpots

A DASHPOT that will not work can cause an engineer all kinds of trouble, and sometimes a great deal of time and energy can be devoted to it without accomplishing much.

When a pot is accurately machined, and the plunger is just the right fit, the chances for a vacuum are good. The method followed in one of the leading Corliss engine works is as follows. The pots are bored and faced on a turret lathe and some stock left for grinding. The plunger is rough turned, and the ends are finished. Pot and plunger are then sent to grinding machines, where the pot is ground to gage; the plunger is afterwards ground to fit the pot. This makes as good a job, mechanically, as can be done. The pots are then placed on a special machine, and go through the same operations as when they are on the engine.



CHECK VALVE AND PET COCK ARRANGEMENT

Some dashpot plungers have packing rings of leather, to aid in attaining a good vacuum; but if there is a good job done in the shop, this is hardly necessary.

The dashpots of a new engine will often give trouble until the steam valves are well seated, and surfaces of valves and valve seats, glazed. Insufficient lubrication will often cause the pots to work stiff, even in an engine which has been long in operation. Sometimes the valve stems are packed too tight, causing friction enough to overcome the vacuum. A valve has often to be placed on the pipe from the cushion chamber, transforming that into a vacuum. A check valve and pet cock, worked in combination on the vacuum, will give good results.

If there are any gaskets in joints or a gasket where pot is fastened to base, there may be a leak, which will give trouble. A paper gasket will, I think, give better satisfaction in the long run, than a rubber one, as the rubber may rot, from action of oil on it.

If the steam pressure is high, and the load is light, the valves, cutting off early in the stroke, will not lift the plungers high enough to obtain a good vacuum. Then they will not drop so far as they ought, and will be pounded down by the steam arm, at the next stroke. This is hard on the engine, besides making a racket that is not pleasing; the best way to remedy this is to cut down the steam pressure. TOM JONES.

Repairing A Centrifugal Pump

FIGURE 1 shows how a centrifugal pump was repaired temporarily. The crack, which was 28 in. in length, appeared on the top of the pump, shown in the diagram at T.

The pump was used to supply the water for a large pulp mill, therefore necessitated quick repair. After some experimenting by the superintendent and millwrights, I asked to repair the pump, which I did in the following manner.

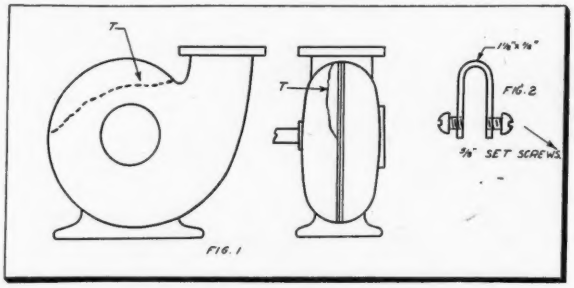


FIG. 1. CRACKED CASE OF A CENTRIFUGAL PUMP
FIG. 2. CLAMP USED IN MAKING REPAIR

Procuring a sheet of lead 7/32 in. in thickness (I might remark that the crack varied from ⅛ to 1/64 in. in width), I cut it into short strips and thoroughly calked the crack, then had 3 braces made like Fig. 2, to force the pump casting where the crack was, as much as possible to its proper position. We then started up and ran all right with the exception of a slight leak, for nearly a month, when a new casting was put in.

G. L. MACLEAN.

DON'T TRY to keep the melted babbit clean, no matter if there is dirt, coal and other refuse on the surface. Let such dirt stay there. Ofttimes it is well to throw in a little dirt of this sort if metal is clean. This is for the purpose of preventing oxidation of the babbit. Oxidation causes a lot of dross to form and uses up a corresponding weight of babbit. Covering the top of the babbit pot to keep air from the hot metal will prevent considerable of the dross forming.—Gas Review.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Packing for Rolls in Rubber Mill

I AM having trouble trying to keep packing in the stuffing boxes on the rolls of mills in a rubber factory.

When the mills are started in the morning steam is turned on to heat the rolls, and when heated, water is put in to keep them from getting too hot. Steam is supplied at about 70 lb. and water at about 35 lb. pressure. In the sketch you will see that the ordinary stuffing box with follower and nut is used. There is room for about 6 rings of ¼-in. square hemp packing. The supply pipe is stationary and the stuffing box revolves with the roll at 30 or 40 r.p.m.

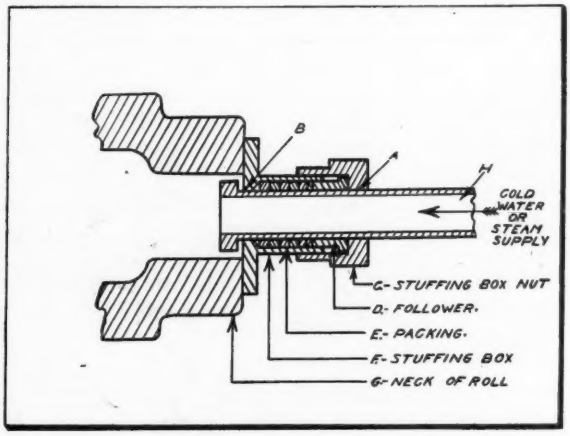


FIG. 1. PACKING GLAND OF ROLL IN RUBBER MILL

There is considerable weight at H, so considerable wear comes at A and B.

Flax packing, well covered with cylinder oil and flake graphite, will last about a week and is not perfectly tight much of that time.

If you know of any packing that will stand steam and water alternately and abuse about half the time I would like to know what you call it and where I can get it. C. B.

A. This is not an easy proposition, for the following reasons:

We cannot use a heat expanding packing, because the temperature is sometimes low. We cannot use a moisture expanding packing, because at times the conditions are fairly dry. We would like to use a combination of the two, but there is hardly space in the stuffing box to do that. A gland pressure packing is being used and is not giving satisfactory results. It should be avoided, anyway, if possible. The only packing that seems to be good, is a diagonal packing, which is an automatic packing, and does not depend on any pressure from the gland. Again we have difficulty here, because the size is ¼ in., and that is too small for really successful results with the diagonal packing.

We will make this suggestion: Buy a diagonal packing, which is 5/16 in. in size, and carefully cut off the sheath, which is braided about the packing. Of the wedges and cushion that are then left, the size should be about ¼ in. Cut rings from these wedges and from the cushions, that will not quite lap around the rod, so as to allow a chance for expansion. Put them in, in the

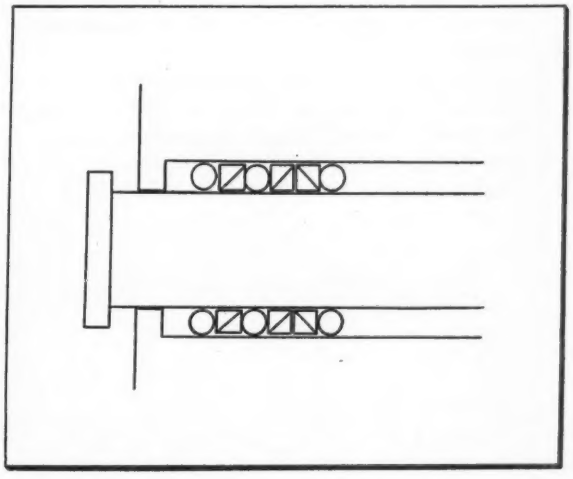


FIG. 2. WEDGE PACKING SUGGESTED

order shown in the sketch; but be careful to stagger the joints on pieces as put in—that is, one wedge will be staggered on the other wedge, and the cushion, in turn, staggered on that.

If these are put in as indicated, 3 complete sets may be placed in the stuffing box. Be very careful to use plenty of oil, when putting them in, so at the start there may be no undue friction. This is not only for the purpose of having the packing work satisfactorily, but also so that there is no chance at the start for the rotary motion to catch certain rings of the packing, and swing them around with the stuffing box itself.

In using this packing, do not come up on the gland any more than is absolutely necessary. The packing should work freely, so that the pressure inside the roll will serve to press the packing against the rod as much as is necessary and keep it working satisfactorily, as well as freely.

You will notice that in inserting this packing, it is placed in a reversed way from the usual steam engine practice. This is because, in a steam engine, the moving

part is the rod and the fixed part the stuffing box. On this proposition the fixed part is the rod, and the moving part the stuffing box.

If this does not work satisfactorily, I do not know any way but to go back to the old method of gland pressure packing. Only, instead of using flax alone, use alternate rings of flax and of round duck, using a very compact round duck, and as solid a flax as can be obtained. Better use what is known as "Water-proof Hydraulic Flax."

I think, however, you will have no trouble if you use the diagonal packing indicated.

W. E. SANDERS.

Drip Piping

I WOULD like to obtain a reliable formula or table covering the size of high-pressure and reduced-pressure drip systems. N. L. S.

A. There is not much data on this point; I suppose for the reason that in high-pressure mains, the drips are usually carried to a separator, where the water can collect, or to a trap, which carries the water off as it accumulates.

One authority states that the waste from a drip of a high-pressure line may be figured at 1/20 of 1 per cent of the steam flowing. For low-pressure systems, with covered steam mains, the following figures are given by the International Correspondence Schools:

FOR PIPE UP TO 2 IN. DIAM.

100 to 200 ft. in length	.....	½-in. drips
400 to 600 " " "	.....	¾ " "
800 " " "	.....	1 " "
1000 " " "	.....	1¼ " "

FOR 4-IN. PIPE

100 to 200 ft. in length	.....	¾-in. drips
400 " " "	.....	1 " "
600 to 800 " " "	.....	1¼ " "

FOR 6-IN. PIPE

100 ft. in length	.....	¾-in. drips
200 " " "	.....	1 " "
400 " " "	.....	1¼ " "
600 to 800 " " "	.....	1½ " "

FOR 8-IN. PIPE

100 to 200 ft. in length	.....	1 -in. drips
400 " " "	.....	1¼ " "
600 " " "	.....	1½ " "
800 " " "	.....	2 " "

FOR 12-IN. PIPE

100 to 200 ft. in length	.....	1¼-in. drips
400 " " "	.....	1½ " "
600 " " "	.....	2½ " "
800 " " "	.....	3 " "

FOR 16-IN. PIPE

100 ft. in length	.....	1½-in. drips
200 " " "	.....	2 " "
400 " " "	.....	2½ " "
600 " " "	.....	3 " "
800 " " "	.....	3½ " "

In his book on "Steam Power Plant Engineering," Gebhardt states that no drip pipe should ever be under ½ in., and that for low-pressure piping, the area of the drip should be 1/5 that of the feed pipe. This would make the diameter of the drip about 0.45 that of the steam pipe, and must be intended as the size for the returns in the low-pressure heating system.

A. L. R.

Low Back Pressure With Double-Pipe Brine Cooler

WE HAVE a 50-ton ammonia compressor here which seems to be in perfect condition; but we cannot run with more than from 0 to 3 lb. suction pressure. When our brine approaches zero, and after it goes below zero, it is 0 or less, and we consider it wise to shut the compressor down then, as opening expansion valves more causes the cylinders to knock and frosts up the machine clear to stuffing boxes and down the frame. I can get good results from the condenser, have tried ranging the pressure from 130 to 225, but run at 175 lb. Our brine cooler consists of 2 stands of pipe 20 ft. long, outside pipe 4 in., inside pipes 2½ in., 6 pipes to the stand. Do you know whether this is sufficient pipe for a machine of this size (50-ton)? We have a 30-ton machine and the cooling coils are the same type, but larger in proportion to the machine, and can get 20 lb. suction pressure with this machine when brine is zero, and 15 lb. when 10 deg. below, which is our limit. E. L.

A. To all appearance, the double-pipe brine cooler is much too small for a 50-ton ammonia compressor. Two stands, 6 pipes high and 20 ft. long, made up of 2½-in. pipe instead of 4-in. pipe, will give a heat-absorbing surface of only 180 sq. ft. This allows about 3.6 sq. ft. for each ton of refrigerating capacity. From 8 to 10 sq. ft. is the allowance made by most builders of this type of cooler.

I assume that the cooler in question is handled in the most common way—i.e., that it is set up in a cold insulated room, or else that the cooler itself is insulated on the outside. If the cooler is submerged in the brine tank, it will prove much more efficient, as you will get the benefit of the heat-absorbing surface of the outside pipe. Whether this would be necessary or not, will depend on the cold-storage load in the plant.

Running the machine with a back pressure of zero is poor economy, as is also opening the expansion valves till the liquid is carried over into the compressor. Raising the condenser pressure will only make matters worse.

Condenser pressure of 175 lb. and 10 lb. back pressure should give good results with a brine temperature of zero. You should test the back pressure gages connected with the 30-ton machine, for it does not look right to have 20 lb. back pressure when the brine is zero, or 15 lb. pressure when the temperature is 10 below zero. The temperature of the ammonia in the coils is about 5 deg. above zero at a pressure of 20 lb. and zero at 15 lb. Either the thermometers or gages are wrong. The ammonia temperature should be about 10 deg. lower than the brine temperature.

Also a coating of oil in the double-pipe cooler will result in the lowered back pressure. If much oil is used in the ammonia compressor and not recovered at the oil trap, it will lodge on the cold pipe surface and act as an insulator. Double-pipe coolers should be blown out with steam and air once a year. Salt brine should not be used in connection with this type of cooler, as the danger of freezing is great. The calcium used in places where such low temperature is required must have a strength of 26 deg. Baume, or 104 on the salometer. If the solution is weaker, it will get thick and travel slow or form a coat of ice on the coils. Weak calcium can also be traced as the cause of low back pressure and freezing up of the machine.

A. G. SOLOMON.

Changing Arrangement of Refrigerating Apparatus

I WOULD like an opinion on some proposed changes I wish to make in this plant, as my liquid valve and receivers are in a little room back of another, and I have to climb over 50 barrels to get at the king valve on shutting down or starting up. By moving the receiver, we will be able to store 100 barrels more, and room counts here.

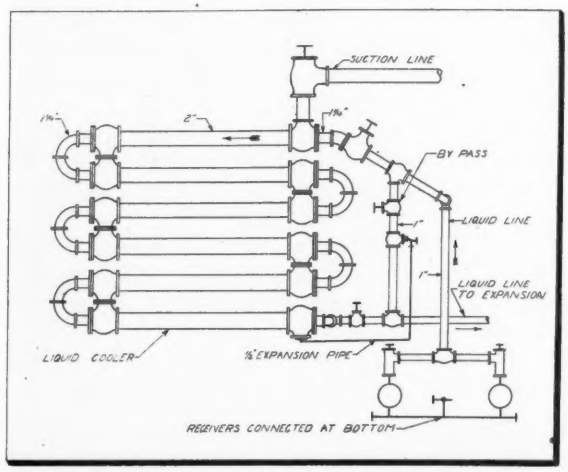


FIG. 1. PRESENT LIQUID COOLING ARRANGEMENT

As you will see from the sketch, the liquid is cooled by expanding ammonia in the outside pipe; but, as I have 2 small rooms next to the compressor, and they frost back too much on my compressors, I intend to run the returning gases in the place of expanding liquid to cool the liquid. Will it work? B. C. W.

A. The proposed change will not work as well as the present cooler and coils, for the reason that the returning or wet gas will fluctuate according to how the expansion valves are opened or closed on the other coils.

It would certainly be a good change to bring all the receivers and expansion valves as near the machine room as possible, and put another master valve near the machine to control the shutting down and starting up, then using king valve only when doing any repairs on cooler.

Oil Supply to Turbine Bearing

AN OIL pump that pumps the oil to the top and middle bearing works at an oil pressure of 120 lb. (Curtis vertical turbine); now, if the oil pressure is raised to 140 lb. per sq. in., the pressure on the outlet side of the baffler remains the same as before; will the volume of oil flowing to bearings be increased?

What is the pressure of oil at the upper bearing?

F. L.

A. If the pressure on the outlet side of the baffles remains constant while the pump pressure has been increased, it is evident that the resistance in the baffles has been increased. The flow of oil, then, remains practically unchanged. If you have experienced this condition, you can readily check this by counting the piston strokes per minute.

The pressure in the upper bearings depends, in any case, on the fit of the bearing. As a limiting case, imagine the bearing to be a perfect, ground fit. With such a condition, the pressure in the bearing would be practically the same as the pump pressure. It is apparent, then, that as the imperfection increases, the pressure decreases.

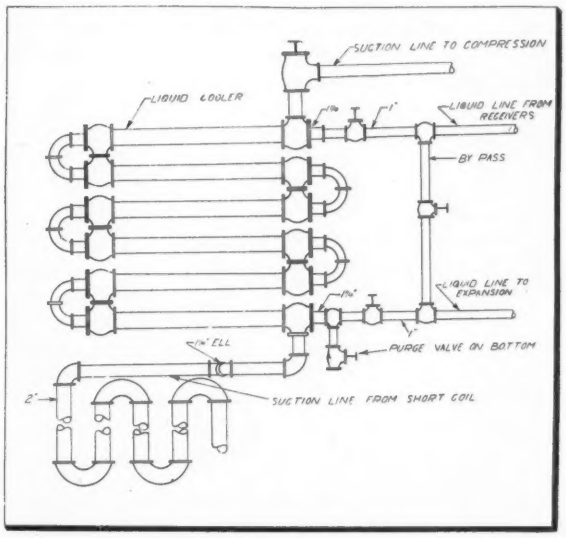


FIG. 2. SCHEME PROPOSED FOR COOLING LIQUID

In one large plant using a number of large vertical Curtis turbines, this baffle to the upper bearings has been done away with. The lines come directly off the oil line to the governor, and in each line to the upper bearing is inserted an ordinary plug valve which is, from time to time, adjusted to give sufficient flow and maintain a pressure of approximately 75 lb. The pressure in the governor line, or on the pump, is approximately 125 lb. E. C. H.

TWENTY MILLION DOLLARS' WORTH of property in the United States was wasted by fire during January. This amount was $4,000,000 more than during the corresponding month of 1913. The loss, as usual, was due in large part to such unnecessary causes as defective chimneys, overheated furnaces, stoves and stovepipes and accumulation of rubbish in basements and cellars.

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Getting Ahead

We are hearing much of the problem of the unemployed—the great number of men who cannot find or cannot fill positions of usefulness. This unfortunate class has probably not a single member among the readers of Practical Engineer. Each of us, however, from his viewpoint at the center of his own working life, is apt to think of his difficulties as greater than those of other men, and his progress toward the higher-paid jobs as intolerably slow and toilsome.

It is undoubtedly the fact that nine-tenths, or a larger proportion, of the men who succeed better than their fellow workers in trade or profession, gain their success by reason of greater effort during longer hours of work. No man can fill a position until he has fitted himself for it. The job he holds generally demands his entire attention for the full working day. Advancement comes to those men only who hold down one job and at the same time fit themselves for another. This means doing double work; not only the daily task, but thought and study after hours, when the average man is tired out, and turns to the "movies," the bowling alley, or perhaps the saloon, for relief and rest.

The stories of early struggles of a few men who became great, were familiar in our school-days. The weaver boy, who studied from a book lying on his loom; the rail splitter, who educated himself at night by torchlight, and others, who rose by tremendous efforts under difficulties that would have been to most men impossibilities. If all were told, nearly every man who gets ahead in his chosen work would be found to have gained his success through extra effort, which other men found too great, and did not attempt.

Technical publications, university extension lectures, correspondence courses, night schools, and other ways of getting the knowledge necessary for advancement, exist today in easy reach of everyone. But only those men who are willing to pay in doubled effort the price always exacted for success, may hope to gain it.

Fire Hazard

Every engineer worthy of the name appreciates his responsibility for safe condition of the steam machinery in his plant, but is safety from fire hazard always as carefully watched? Experience has shown that danger is present even in "fireproof" buildings from the trim and contents, and investigation in plants and buildings often reveals wood construction of "temporary" arrangements that have become a fixture, waste and rubbish, storage and other unnoticed collections of material which offer excellent kindling for the start of a fire from a careless match or spark. While the responsibility for these conditions may not rest with the engineer, he is better able to appreciate the danger, and the disaster that may follow the starting of even a small blaze than those not familiar with mechanical matters, and a suggestion of the possible trouble and of a remedy will often result in removal of the danger, which will give a sense of safety, and will mark the engineer as having in mind the best interests of the entire establishment.

Prevention of fatal or painful injury to even one person is worth a deal of care and thought; and the engineer, or some of his staff, from the nature of their duties, are quite likely to be among the injured if a fire starts. Oil soaked wood, oily waste, loose paper, wood cased steam pipes, shavings,—are a few of the easily discovered and removed trouble starters. It's a good thing to be a pioneer for improvement, especially when your own interests lie in that direction.

News Notes

A $200,000 POWER PLANT was recently completed at Tampa, Fla., by the St. Petersburg Investment Co.

THE MUNICIPAL LIGHT PLANT of Whitesboro, Grayson Co., Tex., which has been in process of construction for the past 8 months, is complete and modern, with a capacity to supply a town of 5000 people.

THE QUANAH ELECTRIC LIGHT & POWER CO. is rebuilding its plant at Quanah, Tex., at a considerable cost. It is also planning to install 4 250-hp. engines, which will greatly increase lighting facilities.

CUERO LIGHT & POWER CO., Cuero, Tex., leased Guadalupe River bed and will construct 2 dams for waterpower development; has one dam, will generate electricity for light and power; the company has invested $240,000 and will increase to $400,000.

AT A MEETING of the National Gas Engine Association, to be held in Chicago, June 24 to 26, the reports of committees will be presented, also technical papers on "Horsepower Rating and Standard Brake Horsepower," "Heavy Oil Engines in Small Units," and commercial papers on "Catalogs," "Cost Accounting," and "Co-operating with the Dealer."

ON APRIL 18, the Twelfth Annual Banquet of the Massasoit Association No. 2, N. A. S. E., was held at the Highland Hotel, Springfield, Mass., with many of the National officers present. H. E. Stone served as Toastmaster, and introduced the speakers, whose remarks were interspersed with entertainment from the orchestra, singers and story tellers.

R. R. SHUMAN has purchased the interest of C. H. Booth in the Shuman-Booth Co., and has formed the Shuman Advertising Co., with headquarters at 620 Westminster Bldg., Chicago. He will retain the old organization, carrying on a general advertising agency business, with special attention to technical and trade journal advertising.

R. W. ANDREWS Co., Monadnock Block, Chicago, has taken the sales agency for the Copes boiler feed regulators and pump governors, and the Neco high and low water alarms, made by the Northern Equipment Co., of Erie, Pa. Mr. Andrews was formerly manager of the Dravo-Doyle Specialty Dept., which position he attained after making an enviable record as traveling representative for the company.

COMPLETION OF the Oxbow power plant, owned by the Idaho-Oregon Light & Power Co., on the Snake River, is made probable through the issuance, by Judge Dietrich, in the United States district court, of an order authorizing the receiver for the company to issue receiver's certificates to cover the cost of the development work. The certificates may be issued in the sum of $250,000.

IOWA FALLS, IA., has voted to grant a franchise for a new heat, light and power company. The present plant is owned by Oscar F. Peterson, of Des Moines.

THE SIXTH ANNUAL CONVENTION of the National District Heating Association is to be held at the Seneca Hotel, Rochester, N. Y., May 26 to 29. During the first 3 days, papers and discussions will be presented on the problems involved in district heating, and on May 29, the delegates will be guests of the American District Steam Co., of Lockport, N. Y., on a trip to Niagara Falls, with a stop at Lockport to inspect the first district heating plant which was installed in that town, and at North Tonawanda for luncheon at the works of the American District Steam Co. The afternoon will be spent at Niagara Falls and will be followed with dinner at the Clifton Hotel on the Canadian side, returning to Rochester in the evening.

ANNOUNCEMENT IS MADE that the United States Steel Corporation and its subsidiary companies propose to have a comprehensive exhibit of its operations at the Panama-Pacific Exposition in San Francisco in the year 1915. It will begin with the ore fields and carry on an educative picture of its operations in ore mining, rail and water transportation, dock operations, coal, coke and pig-iron production, steel manufacturing in its various lines and will also present, in a materially displayed way, the processes of manufacturing of many of its subsidiary companies' products, including "National" pipe; also, how it utilizes its byproducts and the display of many uses in which its general products are employed, typifying the advancement in the uses of this country's resources.

FORMED BY THE CONSOLIDATION of the properties formerly owned by Hiram Grosman & Co., of Dallas, the plans of the Northern Texas Utilities Co., capitalized at $500,000, were announced recently by W. C. Woodlief, secretary-treasurer of the new corporation. Plans for various central stations and transmission lines are now being formulated, but are not ready for announcement at this time, according to Mr. Woodlief. It is the intention of the company to develop and improve the local plants in the smaller towns, and, where practicable, to connect them in districts with high-tension transmission lines, supplied from a single central station for each district.

AT CAPE MAY COURT HOUSE, N. J., Vulcan Electric Light, Heating & Power Co. has begun the erection of a new central plant, having taken over the Stone Harbor Electric Light & Power Co. It is the intention to supply current for electric lights and power to Townsend's Inlet, Avalon, Peermont, Stone Harbor, Cape May Court House and 10 mi. of road lights in Middletown township; also, sand pits of South Jersey Realty Co. and the Stone Harbor Terminal R. R. Co. Work is being rushed to electrify the railroad by June 15. Contracts have been let for one 350-hp. Ames tandem compound engine, noncondensing; one 350-hp. Heine water-tube boiler, one Cochrane feed-water heater, engine to be direct connected to one 275-kw. a.c. and one 125-kw. d.c., 2300-v. stepped to 6600-v. generator. Work has also been started on a transmission line from Cape May Court House to Avalon, a distance of 7 mi. Current will be continuous. This complete outfit will be duplicated by the next year or sooner.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

Transmission of 740 Hp. by Lenix System

AS an interesting example of a large amount of power transmitted in close quarters, there is illustrated herewith a reproduction of a photograph in a large woolen and knitting mill in Europe, where the speed reduction of 5 to 1 is accomplished with a double leather belt, 36 in. wide, using the Lenix drive. The belt was made by Chas. A. Schieren Co., of New York.

Figure 2 is to show that elevation of the drive, with the driving shaft 12 ft. 10 in. below the driven, and the latter on an offset, nearly 12 ft. to the left. This gives a center distance of 17 ft. 6 in. between the parallel shafts, transmitting from a pulley 35 in. diameter, to one 14 ft. 10 in. The Lenix idler was installed to give the belt a greater wrap around the smaller pulley, and the pulley of the idler is suspended by means of 2 link belts or chains, running over sprockets which hang from the balcony above the driving shaft. The free ends of these chains support a series of weights which hang in pits below the floor level, thus permitting the position of the idler to be adjusted as desired and giving it the upward pressure necessary in this particular case. The arc of contact is secured on the driving pulley with about 215 deg., and on the driven about 230 deg., the driving shaft running at 600 r.p.m, and the driven shaft at 120 r.p.m.

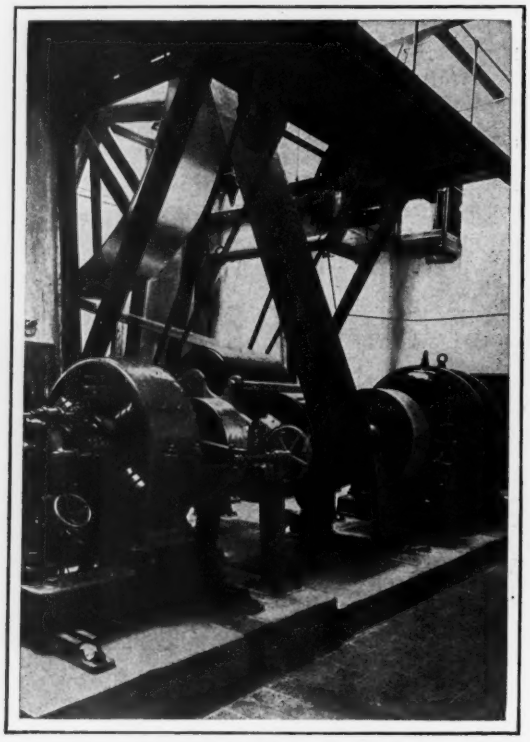


FIG. 1. AN INTERESTING APPLICATION OF THE LENIX DRIVE

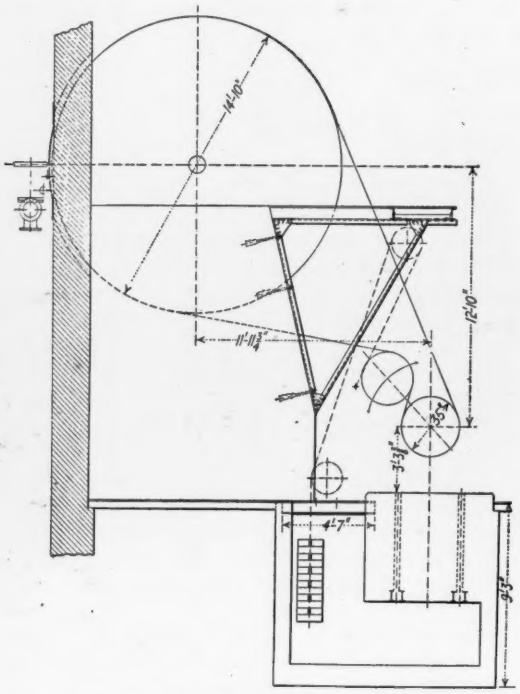


FIG. 2. DIAGRAM OF ARRANGEMENT OF BELT DRIVE IN CLOSE QUARTERS

Williams Feed-Water Regulation

IN the article on the Experiments at the Peoria Plant of the McKinley System, in the May 1 issue, reference was made to the fact that Williams feed-water regulators were not, at the time of our visit there, working satisfactorily. Each of the 8 400-hp. boilers was equipped with such a regulator, and the manufacturers inform us that these were furnished at the time the boilers were installed, 8 yr. ago, and had been in continuous service with, so far as they know, no repairs or renewal of parts. The regulators were guaranteed for

2 yr., and as they have been in service 8 yr., and under conditions which, as stated in the article, have permitted of no shutdowns for repairs and proper attention, it is certainly no discredit to the apparatus that it is not now in the best of condition, and the fact that the regulators are working at all, is proof of their ability to give service, even under the most adverse circumstances.

American-Ball 4-Cylinder Triple Expansion Engine

FOR driving centrifugal pumps, a new high-speed engine of the triple-expansion type with 4 cylinders, is built by the American Engine & Electric Co., of Bound Brook, N. J. The accompanying illustrations show a 1000-hp. engine as erected in this shop. The steam conditions for this unit were 250 lb. initial pressure and 25 in. vacuum.

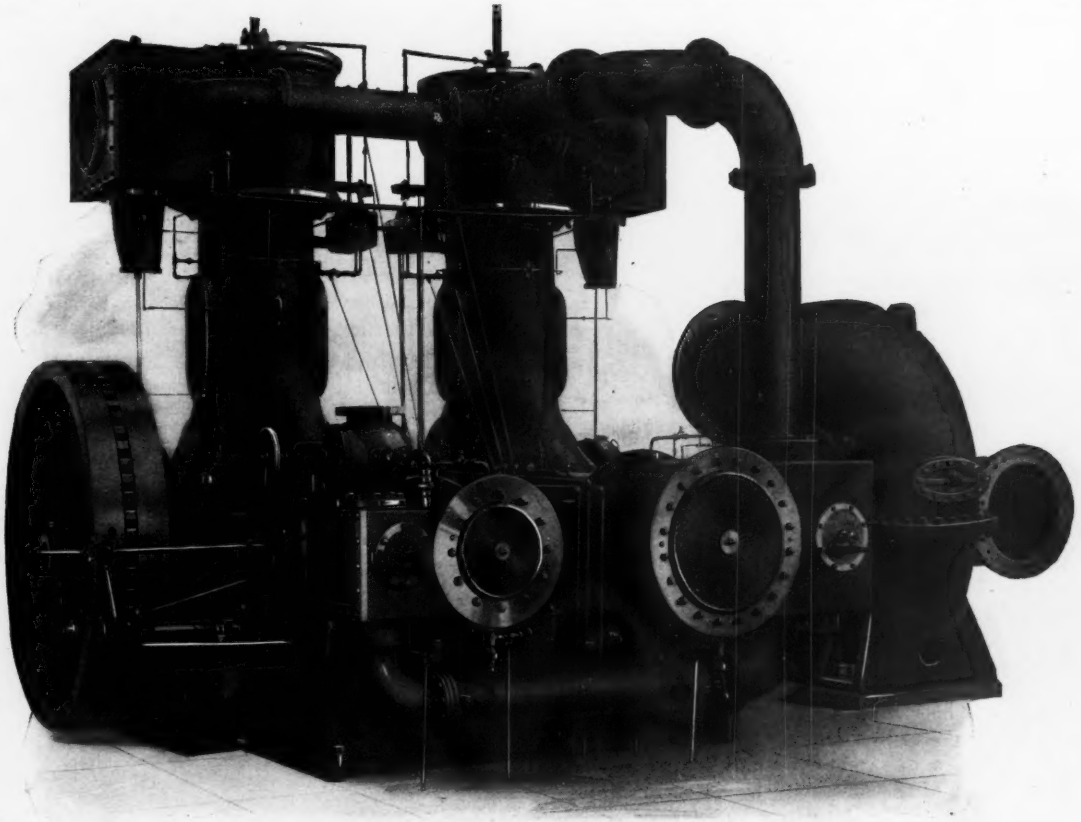


FIG. 1. AMERICAN-BALL TRIPLE-EXPANSION PUMPING ENGINE

The engine is of the double angle type. Figure 2 shows how the 2 engine frames are bolted together and the small floor space required by a 1000-hp. engine of this type.

Referring to Fig. 1, the high-pressure cylinder is in the foreground, the intermediate-pressure cylinder to the right of this, and the low-pressure cylinders are vertical. This construction gives large ratio of expansion and therefore high economy, and eliminates an enormous low-pressure cylinder with massive reciprocating parts. With a single large low-pressure cylinder, the speed would have to be materially reduced and this would increase the size, weight and space required by the engine. The increase in weight would in turn, necessitate decrease in speed, so that as is well known, if a 3-cylinder, triple-expansion engine is to be operated at the high speeds usually desired for driving pumps, the size of the low-pressure cylinder must be reduced, with corresponding reduction in expansion ratio and economy. The difference in economy amounts to several pounds of steam per horsepower-hour.

Higher speeds may be used with the 4-cylinder construction, because of the smaller size of the 2 low-pressure pistons and rods and because the inertia forces of the vertical reciprocating masses are opposed and balanced by equal and opposite forces from the horizontal cylinders. This advantage of the angle construction is well known.

The speeds at which these engines are operated are considerably higher than those of 3-cylinder engines in which economy is sacrificed to reduce the size of the low-pressure cylinder.

Vibration and pounding are eliminated even at high speeds so that the foundations may be light and inexpensive. When this engine is installed on a dredge boat for instance, it is claimed no special stiffening of the dredge is necessary, the engine being simply supported on a cradle of I beams. For stationary plants, a simple block of concrete is all that is necessary. For example, a 1000-hp. 4-cylinder triple-expansion American-Ball

Engine would require about 25 cu. yd. of concrete for its foundation.

The design of valves, pistons, crossheads, rods, etc., of these engines is similar to that of the American-Ball angle compound engines. All parts are supplied with oil from 2 central storage tanks, which may be seen in Fig. 2 between the 2 vertical low-pressure cylinders. The oil collects by gravity, is filtered and then returned to the elevated tanks by 2 pumps operated by the valve gear rocker arms of the horizontal cylinders. One of these pumps with its plunger can be seen to the left in Fig. 1.

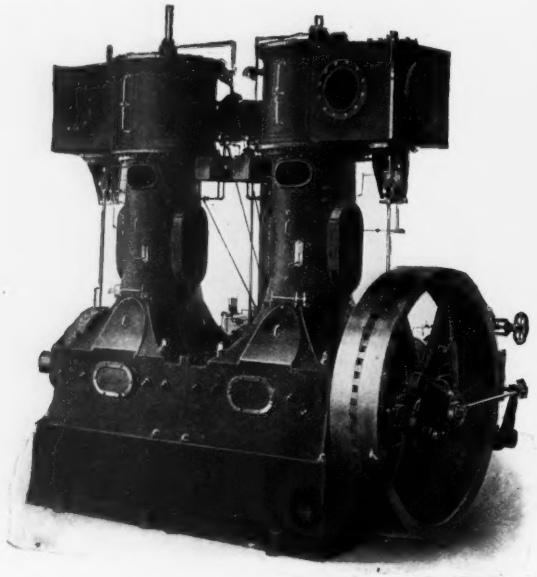


FIG. 2. VIEW SHOWING METHOD OF FASTENING THE FRAMES TOGETHER AND OILING SYSTEM

There are indicator cocks for all 4 cylinders, and a permanent reducing motion on each crosshead. The governor is the standard American-Ball inertia type, of use principally to prevent runaway in case the load is seriously reduced by clogging of the pump inlet.

Quick Building of Large Engines

IN building 2 horizontal, cross-compound blowing engines for the Woodward Iron Co., Woodward, Ala., the first engine was completed and loaded on board cars at the works of the Mesta Machine Co., in 38 days, and the second one in 59 days from the date of signing the contract at Woodward, Ala. Each of these engines contains one high-pressure steam cylinder, 48 in. diameter; one low-pressure steam cylinder, 84 in. diameter, and 2 air cylinders, 84 in. diameter, with a stroke of 60 in.

On Dec. 22 the Mesta Co. had the first engine completely assembled on the erecting floor. On Dec. 23, at about 6 p.m., the engine was loaded on 16 cars, ready for shipment, making just 38 days from the time the contract was signed at Woodward, Ala. The engine was thus completed 53 days ahead of the time called for in the contract.

Arrangements were made with the Pennsylvania Railroad to run the 16 cars as a special train to Cincinnati and with the L. & N. Railroad to take it through as a special from Cincinnati to Woodward, Ala. The train arrived at Woodward on the morning of Dec. 27, 57 hr. from the time it left the Mesta plant.

FIG. 1. AIR ENDS OF LARGE MESTA BLOWING ENGINE

The second engine was completed on the erecting floor on Jan. 12, 1914, was loaded on the cars which left the plant on Jan. 13, just 59 days from the date of signing the contract, and was less than half the time called for in the contract, namely 120 days.

The magnitude of the task is better realized by a statement showing the work handled. The engines weigh 1,800,000 lb., and contain 10,210 pieces. The lightest piece weighs ¼ of the heaviest piece, 94,500 lb.

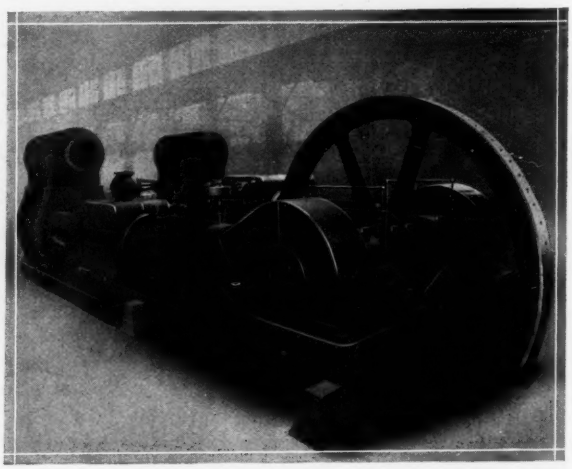


FIG. 2. THE BIG BLOWING ENGINE READY TO SHIP

The engines are designed for 30 lb. air pressure and to run at a speed of 80 r.p.m., to give economical steam consumption, and great volumetric efficiency of the air ends.

The "S-C" Feed-Water Regulator

RECENTLY DEVELOPED TYPE WHICH GIVES CONTINUOUS FEED AND MAINTAINS LEVEL WITHIN LIMITS

THAT water level should not be the first consideration in feeding boilers, has been demonstrated by the use of meters of various types. In order to keep a close water level for varying loads it is necessary to vary the rate of feeding through wide ranges, and this variation in feed more violently influences the rate of steam output from the boiler at a given gage pressure, than either fire or load changes.

The "S-C" vertical feed-water regulator is designed to give these results. It consists of the "S-C" standard balanced valve made for pressures up to 350 lb., having inserted monel metal or nickel seats.

The 1/8-in. pipe tube extending through the generator is connected to the water column or boiler by extra heavy 3/8-in. fittings and nipples, so arranged that its position and location may be varied to meet operating conditions in the plant. This tube contains boiler pressure, the lower part being filled with water to the corresponding level of the water in the boiler, the portion above the water must be filled with steam at boiler pressure, the same as a gage glass.

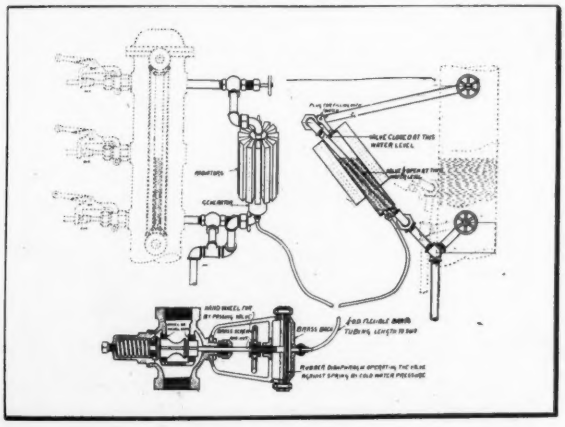


FIG. 1. DIAGRAM SHOWING OPERATION OF "S-C" VERTICAL FEED-WATER LEVEL REGULATOR

Surrounding this tube is a casing or generator which is connected to a diaphragm by flexible, seamless brass tubing, and this entire system is filled with water and sealed.

The water within the tube is exposed to radiation through the fittings and is below boiling point at one atmosphere, while the steam is hot. Hence, any portion of the tube containing steam, will be heated and will boil the water in the generator surrounding it, forming steam pressure in the generator and driving the water through the connecting tubing into the diaphragm, opening the valve in direct proportion to the amount of the tube exposed to steam.

The 2½-in. valve has a 5/8-in. lift, and the tube in the generator is 10 in. long, and this same proportion is carried out in all sizes. Thus, for each inch of tube exposed to the steam, the valve is opened 1/16 in.

Radiation through the thin walls of the generator, assisted by attached radiators, reduces the pressure in the generator as rapidly as the tube fills with water, and the spring on the reverse side of the valve moves it toward the closed position.

If the generator is placed vertical, the water in the boiler must drop 10 in. to open the 2½-in. valve full, while if the generator be placed nearer a horizontal position, the valve will be opened full in relatively closer levels.

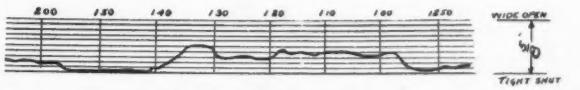



FIG. 2. VALVE MOTION CHART OF REGULATOR ON A 500-HP. STIRLING BOILER

Under ordinary conditions, from 30 to 45 deg. angle is recommended. This position will carry higher level (store heat) on light load, thus helping the boiler and fireman over peak load.

The "S-C" vertical feed-water regulator will maintain a continuous feed. With uniform fire and load it will give a constant feed and water level. On increasing load it will always feed at a lower rate than boiler output, and on decreasing load it will feed above the boiler output, with variation in water level depending on the position of the generator.

For temperatures of feed water above 212 deg. F. (and extremely bad feed water), an outside spring is recommended.

The valve-motion chart shown gives actual valve travel for the period covered. Examination will show that the regulator was giving a constant graduated feed.

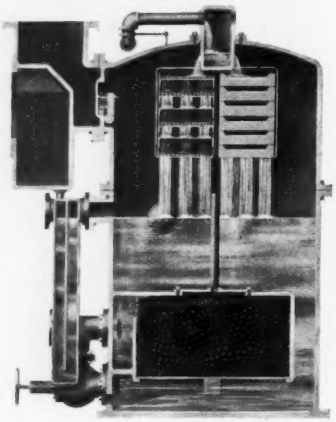
Improved Massillon Open Feed Water Heater

LATEST advances in the science of feed water heating are embodied in the design of the improved Massillon open feed water heater, and the improvements insure a supply of pure hot water for boilers which will minimize fuel and repair bills. Incoming exhaust steam is first passed through an oil separator, to remove oil and entrainment from the steam before it comes in contact with the feed water. From the separator the exhaust passes through an exhaust cut-out valve, all of which is incorporated in the heater, which reduces piping costs and complication. The location is such that all the steam passes through the separator, which is an advantage where some of the exhaust is used for other work than heating the feed water. The control of the valve is by means of a lever, which insures the proper setting of the valve. The heater is operated as an induction heater at all times.

Feed water enters at the top and is delivered to a series of cast-iron, rectangular trays set in cast-iron frames and surrounded by a circular shell. In passing over these trays, water comes in direct contact with the exhaust steam, which has complete access to the trays from all sides, and heats the water to a high degree, which drives off the carbonates and deposits them in the cast-iron trays. A door in the shell enables the trays to be removed and cleaned without difficulty.

Control of the water intake is by means of a seamless copper float, which, if conditions require it, may be adjusted to permit of constant skimming at the overflow. Before entering the coke filter bed the water passes through a settling chamber at the bottom of the heater, thence upward through the coke, which prevents carrying small particles of coke and impurities to the pump valve and out through the pump suction.

A trap is provided on the overflow to prevent sucking back of water when there is a vacuum in the heater. In an emergency, the filter may be bypassed to allow the feed pumps to draw hot water direct from the body of the heater. With the bypass open there is no possible way in which water can be prevented from reaching the feed pump suction, even though the filter should have



INTERIOR OF MASSILLON OPEN FEED WATER HEATER

been neglected until it has filled up solid with impurities taken from the water. The pipe opening into the filter and settling chamber are arranged so that bypass, blowoff, and pump suction can be conveniently and easily connected and operated. A blowoff valve from the settling chamber is provided to remove all sediment which may have settled at the bottom of the heater; also charging doors in the shell of the heater allow of easily refilling the filter bed.

The improved Massillon open feed water heater is manufactured by the Griscom-Russell Co., 90 West St., New York.

FREEPORT, TEXAS, is soon to have a new electric lighting and power system, suitable to meet the needs of this growing seaport. In connection with the new superheated water and power plant now being installed at the Freeport Sulphur Company's mines at Bryan Heights, a new central electric power plant has been recently included in the plans, and will be installed in the next few months. It is announced by the company that this plant, through transmission lines, will supply electric light and power to Freeport.

The amount of electricity furnished will be ample for a large city, meeting all the requirements of the present and for some time in the future. It will take the place of a much smaller plant now in operation here, and do away with the need for any larger plant being installed in the city for a number of years to come.

The electric current, which will be furnished to Freeport and the sulphur mines from this central power station, will be generated by a 200-kw. Westinghouse steam turbine, direct-connected generator set. The use of the turbine engine, connected direct with the dynamo, is one of the most modern and up-to-date methods of generating electric power, and this plant will be a model one for this section of the state.

This central power station will be of proportions to do all the work at the mines at Bryan Heights, where electric power can be used, such as operating electric-driven pumps, to pump water from the canal, and fuel oil from the storage tanks on the Freeport ship channel to the mines, providing power for the machine shop and for commercial and domestic lighting and power at Freeport. The station will be installed by the Westinghouse Church Kerr Co., of New York, in connection with the other new $125,000 developments now being put in at the mines by the sulphur company.

The new sulphur conveyor and loading devices installed by the sulphur company at the Seaboard & Gulf Steamship pier on the Freeport ship channel, which has a capacity of 3600 tons a day for loading vessels with sulphur, is now completed, and ready for operation. It is expected that the first ship load of sulphur to be loaded and shipped from this port, will leave here on one of the Seaboard & Gulf Steamship Co.'s boats within a few weeks.

A new loading equipment for handling this product at the mines has also recently been installed and is now in operation. It consists of a Brown hoist, with a loading capacity of 30 carloads of sulphur a day. With a railroad to the mines, and loading equipment at both the mines and at tidewater, now installed and in operation, the shipment of a considerable tonnage of sulphur from Texas' only sulphur mines can be expected for 1914, and this state from now on can be expected to figure prominently in the production of the world's sulphur.

TRYGVE D. YENSEN, of the Electrical Engineering Department of the University of Illinois, has, for the past 2 yr., been making a special study of electrolytic irons with reference to their magnetic qualities. The aim has been to secure an iron of high permeability and small hysteresis loss, and an iron 4 times more efficient than any now in use has been secured. A vacuum furnace was used for melting the iron, the pressure in the furnace being reduced to about ½ cm. of mercury. Pure iron, when melted in the open air, will absorb a quantity of carbon and oxygen and so be of inferior quality, while iron melted in a vacuum does not absorb any of these elements, but remains pure. Various methods were used in cooling, tests being made to determine the effect of cooling slowly, plunging in brine, in liquid air, etc., each iron being tested to determine the magnetic qualities, metallurgical composition, chemical composition, strength, and critical temperature. Much valuable information has been gained by these experiments, the results of which are soon to be published in the form of a bulletin by the Engineering Experiment Station of the University.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps

APPROXIMATE COST OF PIPE LAYING

AS DETERMINED BY ACTUAL PRACTICE UNDER VARYING CONDITIONS

ITEMS	4 In.	6 In.	8 In.	10 In.	12 In.	14 In.	16 In.
Wt. pipe per length laying 12 ft.	213.	364.	538.	739.	949.	1232.	1496.
Wt. pipe per ft., lb.	18.	30.	45.	62.	79.	103.	125.
Wt. yarn per joint, lb.	.19	.36	.5	.6	.75	.84	1.
Wt. yarn per ft., lb.	.017	.03	.042	.05	.063	.07	.084
Wt. lead per joint, lb.	8.	12.	15.	20.	22.	25.	28.
Wt. lead per ft., lb.	.66	1.	1.3	1.66	1.83	2.08	2.33
Cost pipe per ft. @ $25 per net ton	.225	.375	.565	.775	.99	1.29	1.56
Cost yarn per ft. @ 8¾c. per lb.	.0015	.0026	.0043	.004	.0055	.005	.0075
Cost lead per ft. @ 6¼c. per lb.	.041	.0625	.07	.08	.1144	.13	.1456
Cost cartage per ft. @ $1 per net ton	.009	.0137	.02	.03	.0375	.04	.0590
Cost trenching and refilling, 4 ft. cover	.070	.0712	.14	.15	.1875	.23	.29
Cost pipe laying, caulking and cutting	.019	.0250	.04	.05	.06	.07	.0875
Total cost for average work per foot	.3655	.5500	.8350	1.089	1.3949	1.76	2.15
Additional for shoring per ft., if needed	.06	.08	.10	.13	.15	.17	.19
Cost setting hydrant with 1 length pipe	3.25	3.75	4.50	.....	.....	.....	.....
Cost setting valves and boxes	1.75	1.90	2.15	2.50	3.25	3.50	4.00

Blasting out Rock and relaying various kinds of Paving, or street surfaces, is not included in above.

TABLE OF AIR CONSTANTS

FIGURED FOR DRY AIR AT SEA LEVEL. BAR. 29.92 IN.

Temperature	K	Ratio	Temperature	K	Ratio	Temperature	K	Ratio
—40° F.	3567	890	220° F.	4537	1 132	720° F.	5976	1.491
—30	3609	901	240	4603	1 149	740	6027	1.504
—20	3651	911	260	4668	1 165	760	6077	1.517
—10	3692	921	280	4732	1 181	780	6127	1.530
0	3733	932	300	4796	1.197	800	6177	1.542
10	3773	942	320	4859	1.213	820	6226	1.554
20	3813	952	340	4921	1.228	840	6275	1.566
30	3852	961	360	4982	1.243	860	6323	1.578
40	3891	971	380	5042	1.258	880	6371	1.590
50	3930	981	400	5101	1.273	900	6418	1.602
60	3968	990	420	5159	1.288	920	6465	1.614
70	4006	1.000	440	5217	1.303	940	6512	1.626
80	4044	1.009	460	5275	1.317	960	6558	1.638
90	4081	1.018	480	5332	1.331	980	6604	1.649
100	4118	1.028	500	5389	1.345	1000	6650	1.660
110	4155	1.037	520	5445	1.359	1020	6695	1.671
120	4191	1.046	540	5500	1.373	1040	6740	1.682
130	4227	1.055	560	5555	1.387	1060	6785	1.693
140	4263	1.064	580	5609	1.400	1080	6829	1.704
150	4298	1.073	600	5663	1.413	1100	6873	1.715
160	4333	1.082	620	5716	1.426	1120	6918	1.726
170	4368	1.090	640	5769	1.439	1140	6962	1.737
180	4402	1.098	660	5821	1.452	1160	7005	1.748
190	4436	1.106	680	5873	1.465	1180	7048	1.759
200	4470	1.114	700	5925	1.478	1200	7090	1.770

The figures given under K represent the velocities of dry air in feet per minute required to sustain a column of water 1 in. in height, calculated from the formula:

$$K = \sqrt{\frac{2g \times \text{weight of 1 cu. ft. water at 62 deg. F.}}{12 \times \text{weight of 1 cu. ft. air at temperature stated}}}$$

The values in the column headed Ratio give ratios between the fan speeds necessary for the various temperatures listed and 70 deg. F to produce the same water gage indication.

BLOWER CAPACITY FOR RAW WATER ICE PLANTS

BOSTON TYPE BLOWER

Size Blower	Pulley Dia. Face	Wt., Lb.	R.P.M.	3 Lb. per Sq. In. Capacity*	3 Lb. per Sq. In. Hp.	4 Lb. per Sq. In. Capacity	4 Lb. per Sq. In. Hp.	5 Lb. per Sq. In. Capacity	5 Lb. per Sq. In. Hp.
6x10	16x3	630	750	250	4.9	270	7	260	8.5
6x15	16x3	730	600	316	6.0	.....	.....	.....	.....
8x12	20x4	1400	600	400	8.0	400	10.4	420	13.5
8x15	20x4	1500	550	.....	.....	477	12.3	.....	.....
8x20	20x4	1700	500	599	11.3	.....	.....	.....	.....
10x15	24x4	2150	500	750	15.5	750	21.	840	26.
10x18	24x4	2300	460	.....	.....	927	23.	.....	.....
10x24	24x4	2600	400	1065	20.0	.....	.....	.....	.....
12x18	30x6	3365	450	1250	28.	1250	30.	1346	40.
12x21	30x6	3530	420	1500	26.	1480	35	.....	.....
12x30	30x6	4050	350	1746	31.5	.....	.....	.....	.....

*Cubic feet free air per minute actually discharged.
Capacity proportional to speed.
Power required proportional to capacity and pressure.

CHART FOR CALCULATION OF AIR FLOW

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

SIZES AND CAPACITIES OF TRIUMPH AMMONIA COMPRESSORS

Compressor: Size of Cylinder In.	Revolutions per Minute	*Tons Refrigerating Capacity per 24 Hours: 7000 Cu. In. or 4.05 Cu. Ft. per Min.	7500 Cu. In. or 4.34 Cu. Ft. per Min.	8000 Cu. In. or 4.62 Cu. Ft. per Min.	Horse Power Required	Engine: Size of Cylinder In.	Engine: Type of Engine	Approximate Floor Space for Engine and Compressor Ft. In. Ft. In.	Fly Wheel: Diam. In.	Fly Wheel: Face In.	Fly Wheel: Weight Lbs.	Size of Main Connections: Ammonia	Steam	Exhaust
6 x 8	100	6	5⅓	5	9½	8 x 10	***	8 3 x 6 3	48	8	800	1¼	2	2½
6 x 10	100	7½	7	6½	12	9 x 14		8 9 x 6 11	60	10	1000	1¼	2	3
6½ x 10	100	9	8⅛	8	14	9 x 14		8 9 x 6 11	60	10	1200	1¼	2	3
7 x 11	100	11	10⅓	10	17½	9 x 14		10 1 x 7 5	60	10	2000	1½	2	3
7¾ x 11	90	13	12	11	19½	10 x 16		10 1 x 7 6	60	10	2500	1½	2½	3½
8 x 12	85	14	13	12	21½	10 x 16		10 8 x 7 8	60	10	3000	2	2½	3½
8½ x 12	85	16	15	14	24	10 x 16	SLIDE VALVE	10 8 x 7 8	60	10	3000	2	2½	3½
9 x 12	85	18	16	15	27	11 x 16		10 8 x 7 8	60	10	3500	2	2½	3½
9 x 16	80	22	21	19	34	12 x 18		13 5 x 9 4	84	10	4500	2	3	4
9 x 18	80	25	23½	22	37½	14 x 18	***	13 11 x 9 4	84	10	4500	2	3	4
9 x 18	80	25	23½	22	37½	10 x 30	***	16 9 x 9 9	84	10	4500	2	3	•3½
11 x 18	77	36	34	32	54½	12 x 30		18 2 x 10 6	96	12	8000	2½	3½	4
11 x 20	75	39	37	34	59	12 x 36		20 2 x 10 6	96	12	8000	2½	3½	4
12 x 20	70	44	41	38	65	14 x 36		21 6 x 12 0	120	12	8000	2½	4	4½
12 x 24	70	53	49	46	78	14 x 42		23 7 x 12 1	144	12	12000	3	4	4½
13 x 24	70	61	57	54	92	16 x 36		21 6 x 12 1	144	12	12000	3	4½	5
13 x 30	65	71	67	62	107	16 x 42		24 8 x 12 9	144	12	13000	3½	4½	5
14 x 30	65	83	78	73	124	18 x 42		25 11 x 13 7	168	12	14000	3½	5	6
15 x 30	65	96	90	84	142	18 x 42	CORLISS	25 11 x 13 7	168	12	15000	3½	5	6
16 x 30	60	101	94	88	150	20 x 42		26 2 x 14 10	168	12	16000	4	6	7
17 x 30	60	114	106	100	168	22 x 42		26 8 x 15 0	180	12	18000	4	6	8
18 x 32	55	124	116	109	185	22 x 48		29 0 x 15 9	192	12	22000	5	6	8
18 x 36	55	140	130	122	208	24 x 48		30 1 x 17 1	192	14	25000	5	8	10
19 x 36	55	156	145	136	232	24 x 48		30 1 x 17 1	216	14	30000	5	8	10
24 x 36	50	228	213	200	336	26 x 54	***	33 0 x 19 4	216	14	34000	6	10	12

*The Tonnage capacities are based on the amount of gas the compressors are capable of handling under various conditions and are approximate.
Horse power required is based on 15.67 lbs. evaporating pressure and 180 lbs. condensed pressure.
Belt driven compressors will have face of fly wheel made sufficiently wide to give proper belt contact.
In referring to above compressors and engines use code word.

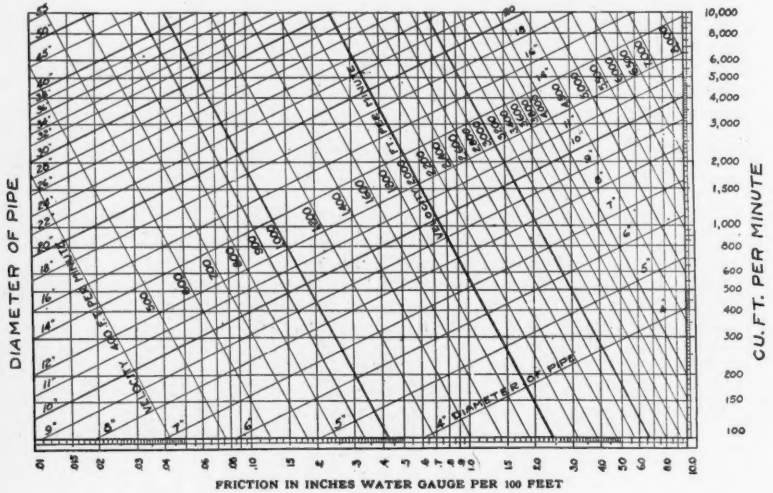
APPROXIMATE COST OF PIPE LAYING

As Determined by Actual Practice Under Varying Conditions

ITEMS	18 In.	20 In.	24 In.	30 In.	36 In.	42 In.	48 In.
Wt. pipe per length laying 12 ft.	1730.	2128.	2735.	2930.	5096.	7200.	8006.
Wt. pipe per ft., lb.	145.	178.	228.	328.	425.	600.	667.
Wt. yarn per joint, lb.	1.1	1.2	1.5	1.8	2.16	2.5	3.
Wt. yarn per ft., lb.	.093	.1	.13	.15	.18	.21	.25
Wt. lead per joint, lb.	32.	35.	42.	53.	63.	84.	96.
Wt. lead per ft., lb.	2.66	3.	3.5	4.41	5.25	7.	8.
Cost pipe per ft. @ $25 per net ton	1.81	2.225	2.85	4.10	5.31	7.50	8.34
Cost yarn per ft. @ 8¾c per lb.	.0081	.0087	.0114	.0131	.0157	.0184	.0219
Cost lead per ft. @ 6¼c per lb.	.1662	.1875	.219	.2756	.3281	.4375	.50
Cost cartage per ft. @ $1 per net ton	.0675	.0837	.110	.15	.1875	.29	.3125
Cost trenching and refilling, 4 ft. cover	.35	.40	.575	.675	.75	1.06	1.25
Cost pipe laying, calking and cutting	.1125	.15	.25	.31	.375	.50	.625
Total cost for average work per ft.	2.5143	3.0549	4.0154	5.5237	6.9663	9.8059	11.0494
Additional for shoring per ft., if needed	.25	.25	.31	.3750	.50	.56	.625
Cost setting Hydrants with 1 length pipe	.....	.....	.....	.....	.....	.....	.....
Cost setting valves and boxes	4.25	4.50	.....	.....	.....	.....	.....

Blasting out Rock, and relaying various kinds of Paving, or street surfaces, is not included in above.
—Wm. T. Angell.

CHART FOR CALCULATION OF AIR FLOW


DIAMETER OF PIPE
CU. FT. PER MINUTE
FRICTION IN INCHES WATER GAUGE PER 100 FEET
DIAMETER OF PIPE
VELOCITY IN FEET PER MINUTE

VOLUME AND DENSITY OF AIR AT VARIOUS TEMPERATURES

Temperature Degrees	Volume of 1 lb. of Air at Atmospheric Pressure of 14.7 lbs. Cubic Feet.	Density or Weight of 1 Cubic Foot of Air at 14.7 lbs. Lbs.	Temperature Degrees	Volume of 1 lb. of Air at Atmospheric Pressure of 14.7 lbs. Cubic Feet.	Density or Weight of 1 Cubic Foot of Air at 14.7 lbs Lbs.	Temperature Degrees	Volume of 1 lb. of Air at Atmospheric Pressure of 14.7 lbs. Cubic Feet	Density or Weight of 1 Cubic Foot of Air at 14.7 lbs. Lbs.
0	11.583	.086331	220	17.111	.058442	575	26.031	.038415
32	12.387	.080728	240	17.612	.056774	600	26.659	.03751
40	12.586	.079439	260	18.116	.0552	650	27.915	.035822
50	12.84	.077884	280	18.621	.05371	700	29.171	.03428
62	13.141	.076097	300	19.121	.052297	750	30.428	.032865
70	13.342	.07495	320	19.624	.050959	800	31.684	.031561
80	13.593	.073565	340	20.126	.049696	850	32.941	.030358
90	13.845	.07223	360	20.63	.048476	900	34.197	.029242
100	14.096	.070942	380	21.131	.047323	950	35.454	.028206
120	14.592	.0685	400	21.634	.046223	1000	36.811	.027241
140	15.1	.066221	425	22.262	.04492	1500	49.375	.020295
160	15.603	.064088	450	22.89	.043686	2000	61.94	.016172
180	16.106	.06209	475	23.518	.04252	2500	74.505	.013441
200	16.606	.06021	500	24.146	.041414	3000	87.13	.01499
210	16.86	.059313	525	24.775	.040364	.....	.....	.....
212	16.91	.059135	550	25.403	.039365	.....	.....	.....

FRICTION OF AIR IN PIPES—Resistance of 90-Deg. Elbows

Radius of Throat of Elbow in Diameters of Pipe.	¼	½	¾	1	1¼	1½	1¾	2	2½	3	3¼	4	4½	5	5½
Number of Diameters of Straight Pipe Offering Equivalent Resistance.	67.0	30 0	16.0	10 0	7 5	6 0	5.0	4.3	4 5	4 8	5.0	5.2	5.5	5 8	6.0

Books and Catalogs

SUPLEE'S MECHANICAL ENGINEERING, Fourth Edition, 917 pages, 4 by 7 in., on thin paper, full leather binding, Philadelphia, 1913, price $5; with thumb index, $5.50.

This book, first published in 1903, has been carefully revised from time to time, and in this fourth edition an appendix of 40 pages has been added, containing the latest information on various subjects, all of which is included in the general index. The first 240 pages are devoted to mathematics and mathematical tables, the next 50 pages to mechanics and mechanical problems, the next 76 to materials of engineering, with tables of strengths and weights, the next 70 to strength of materials and computations for the strength of different shapes and under different loads, the next 70 to machine design, including formulas and data on the parts of machines, the next 30 to heat, then 14 to air, 15 pages to water and hydraulic formulas and tables, 14 to fuels, 12 to steam and its properties, 46 pages to steam boilers, their proportions and operation, 68 pages to steam en- electric power, 10 pages to the cost of power, and 50 pages to the appendix of latest data and progress. The book has won for itself a worthy place in standard engineering literature, and publication of this fourth edition shows the esteem in which it is held by engineers.

SAMPLING AND EXAMINATION OF MINE AND NATURAL GAS. Bureau of Mines, Washington, D. C. By G. A. Burrell and F. M. Seibert.

While this is prepared primarily for the use of those interested in investigating mine gases, it is of great interest to all who have to do with sampling and analysis of gases of any sort.

Proper methods of getting a fair representative sample and the devices used for collecting are shown and described, also the use of apparatus for partial and complete analysis, both laboratory and portable. Results of analyses are given for mine gases and natural gas, with a discussion of the value of natural gas for heating, and for furnishing gasoline.

GENERAL ELECTRIC CO. recently issued Bulletin No. 45,601, describing that company's aluminum lightning arresters for alternating-current circuits. The important features in electrolytic lightning arrester design and embodied first in G-E arresters, are as follows: Oil barriers between cone stacks and tank; iron pipe work as a heat-absorbing and insulating medium; insulating throughout for horn gap structure; charging contacts; charging resistances; transfer switch for interchanging cone stacks for charging; handwheel for operating transfer switch; steel tanks; rim separators for cones; and grounded tank on very high voltages.

The bulletin supersedes the company's previous bulletin on this subject and consists of 32 pages, filled with detailed information relative to these arresters and choke coils for use with them, with notes on the charging operation, installation and ground connections. There are also diagrams and tables of dimensions of both arrester and choke coils.

QUARTERLY BULLETIN of Rensselaer Polytechnic Institute, Troy, N. Y., was recently received.

NEW CIRCULARS from Sarco Engineering Co., 116 Broad St., New York, describe the Sarco steam trap and give names of representative users.

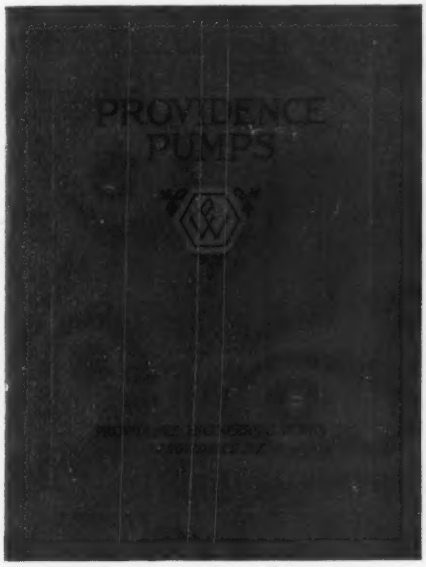
ALBERGER Pump and Condenser Co., 140 Cedar St., New York, has just issued a bulletin, No. 19, on Alberger expansion joints.

FROM SPRAGUE ELECTRIC Works of General Electric Co., New York, we lately received Bulletin 41,010, discussing 2 types of direct-current motors.

Another new pamphlet from the company deals with electric fans.

HOPPES FEED-WATER HEATERS, purifiers, steam separators, oil eliminators, exhaust heads, and V-notch water meters with weighing recorders, are described and illustrated in Catalog No. 50, from The Hoppes Mfg. Co., Springfield, Ohio.

ESSENTIALS OF Providence pumps are described and illustrated in a bulletin recently received, telling how each essential is designed to meet theoretical re-



quirements as well as those relating to practical operation, accessibility and ease of handling. Various features and their purposes are explained in this pamphlet from Providence Engineering Works, Providence, R. I.

SECTION DS842 of the Trolley Line Material catalog, lists and describes various bracket arms for direct and catenary construction. Complete information, together with illustrations, are given of these various types made by the Westinghouse Electric & Mfg. Co.

THE PITOT TUBE and Fan Testing is the title of Bulletin No. 35, from American Blower Co., Detroit, Mich. This gives advantages of the Pitot tube and describes the method, at the University of Wisconsin, of making tests to investigate the reliability of the Pitot tube as a means of measuring the volume and pressure of air or gas in motion, and to ascertain what form of tube gives correct results.

U. S. AUTOMATIC INJECTORS, manufactured by American Injector Co., Detroit, Mich., are illustrated in a new folder giving price lists.

A BOOKLET FROM The Johns-Pratt Co., 553 Capitol Ave., Hartford, Conn., deals with Vulcabeston red fiber sheet packing.

PUSH-BUTTON operated controllers for printers' machinery are described and illustrated in a recent bulletin from Cutler-Hammer Mfg. Co., Times Bldg., New York.

CENTRIFUGAL FIRE PUMPS, horizontal, 2 and 3-stage for 100-lb. pressure, are described and illustrated in Bulletin No. 118, just issued by The Goulds Mfg. Co., Seneca Falls, N. Y.

THE NEW 64-page catalog of The Brown Instrument Co., Philadelphia, Pa., discusses the development and construction of pyrometers, and shows by illustrations where Brown pyrometers are used.

YARNALL-WARING CO.'S latest circular gives a list of Lea V-notch recording meter installations in this country and foreign countries. Those interested may obtain copies by addressing the company at Chestnut Hill, Philadelphia.

OIL FILTRATION is the title of a new 52-page publication from S. F. Bowser & Co., Inc., Fort Wayne, Ind. This discusses the main points of Bowser oil filtering and circulating systems and accessories, and oil storage outfits. The company will be glad to send a copy of the pamphlet to anyone interested.

NEW POWELL extra heavy iron body straightway "Y" blowoff valves, for 250 lb. steam working pressure, are illustrated in a circular from The Wm. Powell Co., Cincinnati, O.

The company is also sending out a booklet of the new Powell Union composite disc valve for steam or hot water heating.

ENGINEERING DEPARTMENT, National Lamp Works of General Electric Co., Cleveland, O., recently issued bulletins as follows: 8E, describing Mazda miniature lamps, including candelabra, decorative, novelty, general battery, gasoline automobile and electric vehicle lamps; 13D, describing Mazda high candle-power multiple lamps, with technical data, accessories and uses; 11B, a discussion of the most recent high-efficiency Mazda lamps for series street lighting service.

Trade Notes

BECAUSE OF the increase of its business, the Swain Lubricator Co., of Chicago, has found it necessary to seek new quarters, and has moved into the new factory which it has built at 443 W. 37th St. Its products are solid grease lubricators, and metallic rod packings for all sorts of conditions.

W. S. HEGER has recently been appointed by the Busch-Sulzer Bros.-Diesel Engine Co., manager of its Pacific Coast Sales Division, with offices in the Rialto Bldg., San Francisco, Cal. He has the assistance of Hugh S. Jones and W. S. Heger, Jr., as sales representatives.

BUFFALO FOUNDRY & MACHINE CO., of Buffalo, N. Y., has discontinued its New York City office, and will handle all business direct from the factory.

PRACTICAL ENGINEER

Trade-mark, Reg. U. S. Pat. Off.

SEMI-MONTHLY

PUBLISHED ON THE FIRST AND FIFTEENTH OF EACH MONTH.

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Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy should be received at Chicago office 18 days before date of publication.

Circulation of this issue, 23,500.

Technical Publishing Co.
537 S. Dearborn Street
Chicago

Position Wanted

POSITION WANTED—As Chief Engineer in Institution, with 10 years' experience in Institution work. Can give best of reference. C. H. Mitchell, 1403 Congress St., Portland, Maine. 5-1-2

POSITION WANTED—As Gas Engine Operator. Have had 4 years' experience. Can do all repair work. Address Box 46, Morton Grove, Ill. 5-15-1

POSITION WANTED—By industrious and capable young man as engineer in power station. I. C. S. graduate. 5 years' exp. on large reciprocating units and large steam turbines. A. C. and D. C. apparatus. At present engineer in large power station. Chicago license. A1 references. Address Box 347, Practical Engineer. 5-15-1

POSITION WANTED—As Engineer of Water Works, Ice Plant or Electric Light Plant. Town of 2000 or 3000. South preferred. 8 years' experience installing and operating. References, R. R. Ricoss & Son, Jensen, Fla. Address T. R. Christian, Salerno, Fla. 5-15-1

POSITION WANTED—By young man as assistant or oiler. First class. Minnesota license. 7 years' experience. References of the best. Correspondence invited. Guy Bilyen, McGregor, Minn. 5-15-1

POSITION WANTED—With Engineering Supply House, by young man who holds I. C. S. diploma; also second class Mass. fireman's license and has two years' experience. Address Edward S. Daniels 113½ Bridge St., Salem, Mass. 5-15-1

POSITION WANTED—As Chief Engineer or assistant in small town. Refrigerating experience. Best of references. Licensed in Chicago. Address M. J. W., 1951 W. Jackson Blvd., Chicago, Ill. 5-15-1

Wanted

IF YOU RECOGNIZE the value of approved specialties in an engine and boiler room as a means of higher efficiency; if you believe in this sort of thing to the extent that you think you could sell a well-known boiler specialty in your territory for an old-established manufacturer in the power-plant field, write and tell us all about yourself. On receipt of your letter we will outline our proposition in full. Address Box 324, Practical Engineer. tf.

WANTED—By a large company, an experienced and capable man who thoroughly understands his business, to take charge of a department working about one hundred men, making elevator cars and enclosures. Box 348, Practical Engineer. 5-15-1

WANTED—A small ice-making and refrigerating plant with a daily capacity of about 10 to 15 tons is wanted by a subscriber. A second-hand plant preferred. Give full particulars. Address Box 341, Practical Engineer. tf.

WANTED—Every local Engineers' Association to have an assortment of valuable power-plant books—Secretary, write at once, for full particulars. Address Dept. C, Practical Engineer, Chicago.

IF YOU ARE a night engineer, spend a few hours each day taking subscription for Practical Engineer. You will be paid well. Write Subscription Dept. They will start you in at once.

WANTED—ALL STEAM USERS to have clean boilers without using compounds or chemicals in any form. Write "Otis," No. 317 Norfolk Ave., Buffalo, N. Y. tf.

WANTED—Secretary of local Engineers' Association to write at once in regard to a very interesting proposition. Address Practical Engineer, Circulation Department.

Help Wanted

WANTED—A competent, reliable and experienced chief engineer to take charge of power plant for saw mill and electric driven planer in South. Must be first class electrician and Corliss Engineer. Give reference in first letter. Address Box 344, Practical Engineer. 4-15-2

WANTED—An additional subscription solicitor wanted to cover towns in the State of Oklahoma. Excellent chance to earn extra money. Write to Subscription Department. tf.

For Sale

FOR SALE—One 95-hp., 3-cylinder Westinghouse producer gas engine and complete equipment for operating suction type. Constant use one year. Practically new. Address Box 345, Practical Engineer. 4-15-6

SPECIALS—Two 75-kw. Westinghouse, 125-volt dynamos, direct connected Ames automatic engines, each $975. Two 75-kw. Cocker Wheeler, 250-volt generators, direct connected Harrisburg Fleming engines, with switchboards, each $1200. Also 350-hp. Heine watertube boilers (30 days' service), 200 lb. steam pressure, $1500. Duzets & Son, 50 Church St., New York. tf.

FOR SALE—2 Buckeye steam engines at bargain prices. 1 12x21-in., 85-hp., 185 r.p.m., 85-lb. steam pressure, flywheel 6 ft. diameter, 22-in. face. 1 11x18-in., 70-hp., 200-r.p.m., 85-lb. steam pressure; flywheel 4 ft. diameter, 14-in. face. Changed to motor drive. Must move at once. Write today. The W. H. Mullins Co., Dept. A., Salem Ohio. 4-15-6

TRAVELING CRANE—Wooden—For Sale Cheap. 15-ton capacity, 65-ft. span, suited for either motor or wire rope drive. Write Box 346, Practical Engineer. 4-15-6

FOR SALE—Complete rope-drive transmission, with clutch, sheaves, hangers, etc., for use in straight or angle driving. Angsten-Koch Company, Chicago. 5-15-1

DYNAMOS, Motors, Small Motors, dynamos, parts, storage batteries, for all purposes. Send for catalogue. Fred R. Heilman, 442 Niagara St., Buffalo, N. Y. 5-15-1

Patents and Patent Attorneys

PATENT YOUR INVENTION. Send sketch for free expert search and report as to patentability. Books on inventions and patents, and book of references from congressmen, manufacturers, bankers and inventors sent free. John S. Duffie & Co., 612 F St., N. W., Washington, D. C. tf.

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 McGill Bldg., Washington, D. C. tf.

PATENTS THAT PROTECT AND PAY. Advice and books free. Highest references. Best results. Promptness assured. Send sketch or model for free search. Watson E. Coleman, Patent Lawyer, 624 F St., Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact cost. Send for full information. tf.

OFFICIAL DRAWINGS FREE. Patents procured or fee returned. Expert services. Send sketch for Free search. The Patent Exchange, Garban Bldg., Washington, D. C. tf.

FOR HONEST advice and real patents at Low Cost, consult John O. Seifert, Patent Attorney, 50 Church St., New York. 5-15-6

NO Attorney fees until patent allowed. Send sketch for free report. Books free. Fuller & McLachlen, Washington, D. C. 5-15-2

PATENTABLE IDEAS WANTED—Send for 3 free books. R. B. Owen, 28 Owen Bldg., Washington, D C. tf.

Educational and Instruction

ENGINEERS' POCKET MANUAL, 175 pages, edited by University of Tennessee, will be mailed every subscriber sending in NEW subscription (not your own) to Practical Engineer. Gilt edges; bound in leather.

Miscellaneous

ENGINEERS—DO YOU WANT to utilize your exhaust steam for heating or drying purposes, without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill. tf.

MAKE MONEY on the side. Here's your chance to work out some money for yourself. Get subscriptions for Practical Engineer. It pays well. Just drop a line to the Subscription Dept. They will tell you. tf.

Sparks From The Advertising Pages

Down at Vera Cruz, where Uncle Sam is visiting, it was necessary for the naval officers to temporarily take over the administration of the city government, the Mexican city officials having refused to serve under American supervision.

Admiral Badger put several of his naval officers in charge of the Customs, Police, Postoffice, Sanitation and other Municipal and Governmental offices.

Press dispatches reported that the administration of these offices was accompanied by a thoroughness surprising to the Mexicans.

The average man's conception of the duties of a Naval Officer is the direction of fighting ships and fighting men. This is correct, but incomplete, for at Annapolis our naval officers are prepared for civic, health and constructive work, as well as for military tactics.

The training given our Army Officers at West Point has indebted the world to them for many accomplishments out of the realm of the military. To realize this, we have only to recall that Army Officers were in charge of the work of the Panama Canal; and that they are filling the posts of health commissioner for Chicago and other large cities.

Being prepared is a state in which every man should live.

An engineer of a power plant should be prepared. He should have a plan of education to obtain knowledge far in advance of that required in the operation of his plant.

He should have, for instance, a system of keeping power plant costs which will tell, at a glance, just how much his power is costing and where the cost is located.

He should have a knowledge that will fit him for an intelligent selection of power plant equipment to bring down operating costs and raise plant efficiency.

Are you so prepared? Could you, today, completely advise your employer, or the board of directors, on all power plant problems, new equipment or remodeling the plant? Or, would you have to make a study of length before you could give this information?

Being prepared increases your value to yourself and to your firm.

The advertisements in Practical Engineer will help you to keep prepared. In them you will find messages of the latest in prime movers and auxiliaries for power plant use.

The manufacturers, of course, are unable to tell all about their products in the limit of one page, but they do give sufficient information to interest and instruct, and they offer more for the mere request.

The reading of advertisements is a good habit to form. It can harm no one, but on the contrary, it has helped thousands of engineers to better their power plants and their position and prestige.